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VOL. I · NO. 1

PUBLIÉ PAR LE BUREAU DU CONSEIL

RÉDIGÉ PAR

E. S. RUSSELL

EN COMMISSION CHEZ
ANDR. FRED. HØST & FILS
COPENHAGUE

FÉVRIER 1926

Note.

The Journal of the Council will, it is hoped, appear quarterly, and four numbers will form a volume. It will include in addition to general articles, reviews and bibliography, the special papers hitherto issued in the series of "Publications de Circonstance".

The subscription price has been fixed provisionally at 15 Kroner per volume, which will include, if desired, a reprint of the bibliographical matter, printed on one side of the paper. Single copies will be sold at Kr. 4,50.

Contributions to the Journal should be sent to the Editor: —

Dr. *E. S. Russell,*
43, Parliament St.
LONDON. S.W. 1.

They may be written in English, French, German or Spanish. General articles and reviews will be paid for at the rate of 10 Kroner a page. Authors of general articles and scientific papers will receive 50 copies of their paper gratis.

Books and papers for review or bibliographical notice should be sent to the Editor.

Orders for copies should be sent to Messrs. Andr. Fred. Høst & Søn, Bredgade, Copenhagen, and business communications, regarding advertisements, etc. to the General Secretary, Strandvej 34, Copenhagen.

CONSEIL PERMANENT INTERNATIONAL
POUR L'EXPLORATION DE LA MER

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Editorial Note.

In presenting this, the first number of the Council's Journal, the Editor wishes to renew his thanks to all those who have rendered him assistance by advice and in other ways in starting this new venture.

A few words as to the scope and contents of the Journal may not be out of place. Except in one particular, the present number is typical of those to follow — each number will contain a general article on some aspect of the Council's work, one or two short scientific articles such as have hitherto been published in the »Publications de Circonstance« (which series will now be discontinued), notes on current work, reviews and a current bibliography.

In the present number the place of the current bibliography is taken by Part I of a Selected Bibliography of fishery and general publications, for which the Editor is greatly indebted to Dr. E. J. Allen. Part II will appear in the second number of the Journal, and the Bibliography as a whole will, it is felt, form a useful basis for the current bibliography, publication of which will begin in No. 3 with papers received in 1926.

It is proposed to re-issue Dr. Allen's Bibliography when complete, as a separate publication, with the items printed on one side of the page only.

Starting with No. 3 of the Journal, the current bibliography will be issued to subscribers to the Journal in the form of sheets printed on one side only, as well as being printed in the Journal in the ordinary way.

Fluctuations in the year classes of important food fishes

by

Johan Hjort.

Introductory remarks.

From the earliest times a characteristic feature in all branches of the fishing industry has been the fluctuation of the respective yields from year to year. The history of the mackerel fishery of the United States, the sardine fishery of France, and all the important Norwegian fisheries gives a long series of demonstrations of great fluctuations in the yield of the catch and in the means of subsistence of the fishermen in these countries.

For centuries these fluctuations have occupied the minds of the fishing population, and innumerable hypotheses and suggestions have been put forward by way of explanation. The earliest attempts at an explanation of the fluctuations in the fisheries naturally took as their starting point the fact that the fish were not always to be found in the coastal waters. These facts gave rise to the theory of migrations, and fantastic ideas about the extent and irregularity of such migrations have for centuries played a great part in the public discussion.

The enormously increased knowledge of the sea, and of life in the sea, that has accumulated during the last fifty years — partly through the experience gained by the great oceanographic expeditions, and partly from the systematic biological investigations of fish and fisheries — have gradually changed the whole foundation of these theories of enormous migrations. Through the studies of the racial characters of the fish in different geographically defined areas, the understanding gained ground that the area of distribution of a certain species did not coincide with the area of migration of the individuals belonging to the species. In other words, that all the important species of fish were subdivided into a number of populations, which can be morphologically

distinguished, and which have a limited area of distribution. The marking of fish in different waters gave the experimental proof of this understanding and developed the new and important idea, that the study of fluctuations should primarily be concentrated, not on the study of the species, but on the investigation of the stock of fish in a certain geographical area.

In a lecture delivered at the meeting of the International Council for the Study of the Sea in 1907, I endeavoured to formulate such a programme of work in the following words[1]):

"I will proceed to draw a comparison between this Fishery Research and a science which is much more generally understood. I mean the science of Vital Statistics.

In all expositions of the science of vital statistics there are three prominent features which attract our chief consideration: 1. Birth rate. 2. Age distribution. 3. Migration. It is customary to study these questions by the help of what are called representative statistics. A certain number of individuals are selected that are supposed to stand for the mass of the people, and attention is directed to them. We ascertain from this source their average length of life, their wanderings, their increase or decrease, and whether sickness, war, disaster, or emigration play any appreciable part in reducing the population.

It seems at first sight a bold suggestion to propose the study of the fish supply on lines like these. A population can be counted; but who knows how many fishes are in the sea? And yet it appears to me a project great in possibilities, to regard the discoveries of fishery research from a similar standpoint to what has been adopted in the science of vital statistics".

In the period of years from 1901—1914 I tried to follow up this programme in the study of the stock of cod and herring in the Norwegian waters, in co-operation with the following gentlemen: P. Bjerkan, H. Broch, K. Dahl, D. Damas, B. Helland-Hansen, Thor Iversen, E. Koefoed, F. Lea and Oscar Sund, who were then for a longer or shorter period my assistants at the laboratory for fishery research at Bergen. The main results of this co-operation have been summarized in two publications[2]) and may be stated as the recognition of the following facts:

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[1]) "Some Results of the International Ocean Researches" published by the Scottish Oceanographical Laboratory, Edinburgh, 1908.

[2]) Rapport sur les travaux de la commission A. Rapports et Procès-Verbaux Vol. X 1909. Fluctuations in the great fisheries of Northern Europe. Rapports et Procès-Verbaux Vol. XX 1914.

1) That the stocks of cod and herring include a far greater number of year classes than had previously been supposed, and
2) That the relative numerical values of these year classes exhibit great fluctuations from year to year.

In the last mentioned publication of 1914, I defended the theory that the fluctuation of year classes was to be considered as a prominent, perhaps the predominating factor determining fluctuations in the fisheries.

In the present article I propose to review the position of the problem of to-day. It is by no means my intention to give an exhaustive exposé of the now very extensive literature on the subject, which in itself would be impossible in a short article. My purpose will be to analyse, by means of examples, how far it may be possible, by representative statistics, to obtain a reliable valuation of the stock of fish in a given area of the sea, and how far the fluctuations of the year-classes within the stock, as they appear in our representative statistics, correspond with changes that have actually taken place in the catches of the fishermen from year to year.

I shall here to a great extent confine myself to the experiences obtained by the study of the Norwegian fisheries, as it seems of great advantage to the problem to compare the results which were already published (in 1914) with the later experience of continued investigations. We shall in this way — so to say — be able to subject our theories to the test of the events which have taken place in nature since the first statements and predictions were made. It is for this purpose of the greatest value, that the important task of collecting material for the description of the stock has been continued for a long series of years. The stock of herrings has been investigated by Mr. Einar Lea and the stock of cod by Mr. Oscar Sund. The material collected has been published by these gentlemen in the official yearly administrative reports[1]). Mr. Oscar Sund has also had the kindness to place at my disposal a memorandum on his present methods of treatment of the material.

Herring and Cod off the Norwegian coast.

The indispensable basis for the study of the vital statistics of a stock of fish must naturally be the preceding investigation of the life history of the population, the migrations and behaviour of the individuals of

[1]) Aarsberetning vedkommende Norges fiskerier utgit av Fiskeridirektøren, Bergen.

the different year-classes, and the extent of distribution; i. e. the geographical area to which the population is confined. Vital statistics are then concerned with the whole mass of the population within this area.

Even the first biological investigations of the fish in Norwegian waters (Boeck, G. O. Sars) revealed the important fact that the populations of herring and cod appear in shoals, consisting of individuals all belonging to what one might consider to be "biological groups of the population". During the first three or four months of the year, large shoals of herring and of cod appear along the west coast. In these shoals, all the individuals are mature, with ripe or nearly ripe "roe or milt", and the fish collect on the old banks known through centuries for the purpose of spawning, after which process they suddenly disappear again. The catches of the fishermen contain at these places practically no other herring or cod than the mature individuals. In other shoals, which mainly appear in summer time, and in increasing numbers from south to north, we find groups of the population consisting only of the younger, immature individuals. The immature fish belong to several biological groups. There seems to be a distinct grouping together of individuals according to size, and not always according to age; i. e. the larger individuals of one year-class may have a tendency to go with the smaller individuals of an older year-class rather than with the smaller individuals of the same year-class. The activity of the fish, its ability to swim, and the special sort of food it seeks, may be the deciding factors for the grouping together of the individuals. In this way we get several groups, the pelagic stages in the first year of life, the first bottom stage of the cod, and the shore-water stage of the herring in the second year, and then several groups of individuals of different sizes both of cod and herring in the following years before the fish reaches the state of maturity. The spawning shoals of both species may contain individuals from some 5, 6 or 7 years up to over 20 years of age, i. e. more than 13—15 different year-classes.

The distribution and the appearance of the different shoals may be understood in a schematical way by the following sketch of the main features in the life history of the fish.

The Cod.

The mature fish undertake extensive migrations — thousands of kilometers — during the course of the year. In the year 1913 I marked some thousands of spawning cod from March to April on the Lofoten Bank. Many of these (see Figure 1) were found off the coast of Finmarken

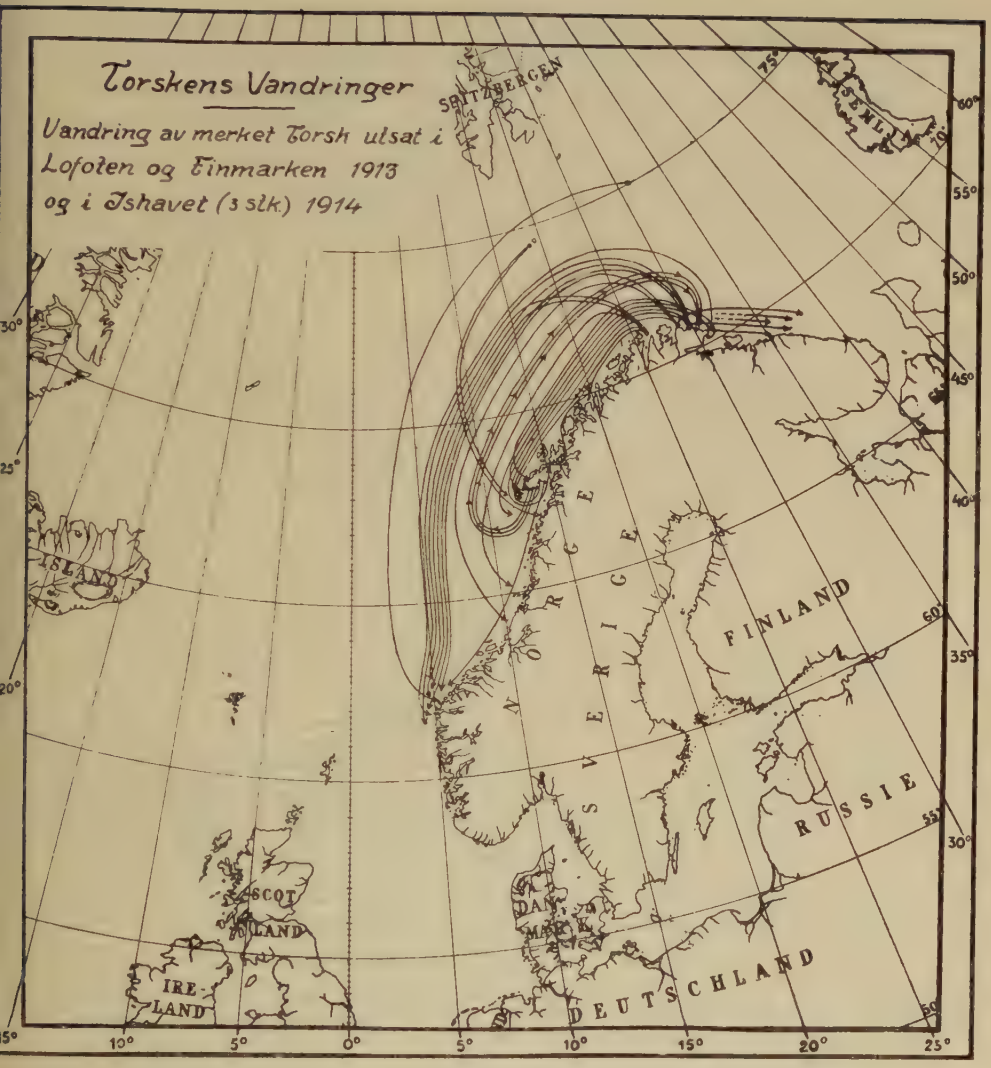

Fig. 1. Migrations of mature cod marked in Northern Norway in the year 1913, some in Lofoten in the Spring, others in Finmarken during the summer.

some 5—6 weeks later. Of cod marked in the early summer of the same year off the coast of Finmarken, some were found migrating eastward off the Murman coast towards the White Sea in the summer, and in the following spring on the spawning banks off the west coast as far south as about the Cape of Stat. There is thus a yearly migration from the Barentz Sea southwards along the Norwegian coast, and again a migration northwards back to the Barentz Sea. Within this large area

there may be great variations in the direction of the migrations, in some years more to the east, in others more to the north, even as far as Spitzbergen, where there were great cod fisheries in the eighties, and where the fish again after a long series of years has made its appearance.

The eggs of the cod, which hatch on the spawning banks, soon begin to drift. They get into the strong current going north along the coast,

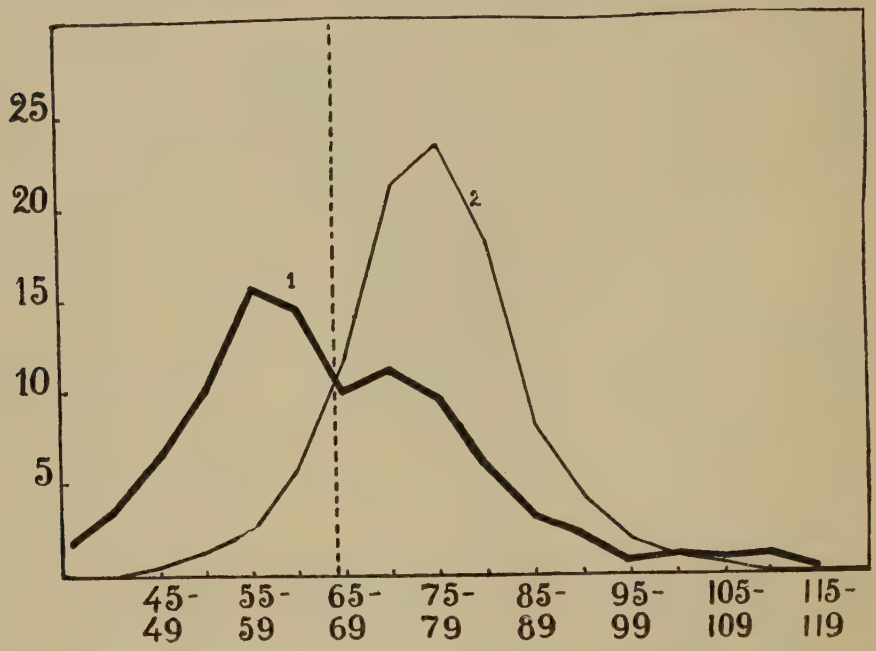

Fig. 2. Curve 1 shows the composition in point of size (percentage) of 9000 Finmark fish measured in 1901, 1903, 1905, 1906, 1909 and 1913. Curve 2 shows composition in point of size of skrei.

while they develop into young fish some inches in length. One may then, as I did in 1900, find them more than a hundred miles off the coast, and most of them are carried far north to the Barentz Sea. Many of them reach the coast, many more are disseminated over the large area between the Norwegian coast and the semicircle of cold polar water which limits the distribution of boreal forms of life to the North and East in the Barentz Sea. Here the young stages lead a very local existence, until they attain such a size that they can begin to migrate about and follow the big shoals of the capelan which every spring migrate towards the coast of Finmarken. In the months from April to June, we then find the young cod (3—6 years of age) which are immature, and collect for feeding on the capelan or schizopods of the coastal waters.

In some years, we find only such young fish in the catches of the Finmarken fishing, in other years, an admixture of larger mature fish returning from the spawning areas, and in some years, again this contingent of large fish may entirely dominate and form the whole basis for the fishing. Figure 2 gives one example of the sizes (in centimeters) of the Finmarken fish (Curve 1) and the spawning fish (Lofoten 1913). Both curves are, as we shall see presently, subject to great variations from year to year.

The Herring.

The life history of the herring has some important similarities to that of the cod. The spawning shoals collect in the spring months on certain banks off the west coast of Norway. We have no such definite information as for the cod concerning where the spent individuals go when they leave these banks. It seems an important problem to look for them on the so-called Bottlenose field east of Iceland and North of the Faeroes, where I have found herrings on several occasions (See my paper on Fluctuations Fig. 3 page 8).

The young larvae hatched from the demersal eggs are carried northwards, like the larvae of the cod, but not so far as to the Barentz Sea. The waters of Northern Norway may be considered to be the nurseries for the herring during its first 4 or 6 years. We there find small herring and fat herring of different sizes in the different shoals which form the basis of the fat-herring fishery. When the herring approach the state of maturity, they begin to migrate southwards, and they then mix with the shoals of the older year-classes. The appearance of these shoals takes place with considerable regularity. The herring are called large herring on their way southwards, and spring herring when the genital organs are ripe, and the shoals appear on the old spawning banks.

These remarks may suffice for the following discussion of the fluctuations in the stock.

Fluctuations in the herring fisheries of Norway.

The fact — mentioned above — that the herring and cod of the Norwegian water appear — in any case at certain times of the year — in separate biological groups, seemed to us from the beginning of our studies of the fluctuations to offer this great advantage, that the same group, i. e. that of the spawning fish, could be compared from year to year, isolated from all the other stages of the population. It was, however,

also from the very beginning quite evident that the question as to how far our samples could be considered as representative of the biological group under investigation would have to be subjected to a critical analysis. It had here to be borne in mind that even if a sample collected from one shoal spawning on a definite small bank off the coast were representative of this shoal, it could by no means be anticipated that the sample would also represent the whole mass of fish spawning over an extent of hundreds of miles.

Fig. 3. Localities of capture of the samples 1—7 large herrings, 8—15 spring herring samples.

To analyse this question, it would be necessary to collect a great number of samples, and to compare their composition with regard to the different year-classes. This work was done from the year 1907 onwards, and many tens of thousands of scales have been investigated for the determination of the age of the individuals in the samples. Mr. Einar Lea has during the past years borne the greatest part of the burden of this enormous work. In my paper (Fluctuations 1914, page 218 ff.) I gave some examples of this work, which may be referred to here. In figure 3, we find the geographical position of the places where 15 samples, altogether comprising 3711 herring, were collected in the winter of 1913—1914. The samples numbered 1 to 7 were large herring, the samples 8 to 15 spring herring. In figure 4, the age composition of the last 8 samples is illustrated. I described these samples in the following words: "The reader will doubtless be surprised, as were those concerned in work-

ing out the results, to note the close agreement between the different samples as regards their composition in point of age". The percentages of the predominant year-class, that of 1904, were in the samples 8 to 14, which were collected from the shoals of true spring herring as fol-

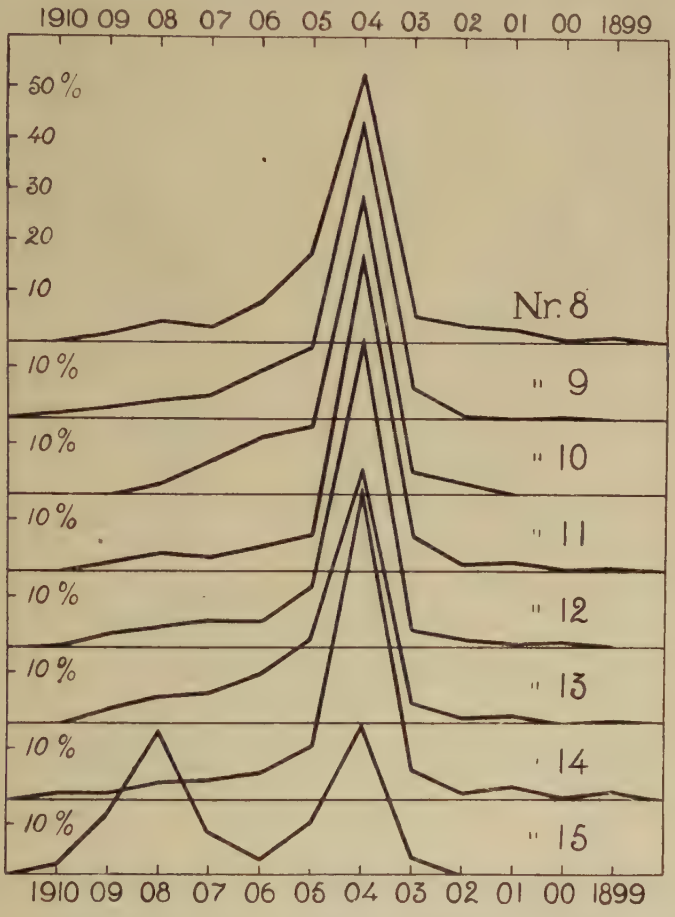

Fig. 4. Composition in point of age of spring samples February 1914.

lows: 52.6, 58.4, 59.1, 62.3, 60.7, 50.2, 62.2. The sample no. 15 indicated that peculiar conditions prevail in the Skagerack, which may represent a borderland of the area of distribution of the stock off the Norwegian west coast.

The example given here has been found to be in close correspondance with the experience from the extensive collection of other samples. As a summary of the results of the investigations of the spring herring during the years 1907—1914, I gave in my paper the figure, reproduced

here as figure 5, where we find a picture of the important part which the 1904 year-class has played in the spring herring stock in these years. "In 1907 there were no less than 5 fairly richly and fairly evenly represented year-classes (the 4—8 year old fish). This even proportion is broken in 1908 by the appearance of the 1904 year-class, which in the following

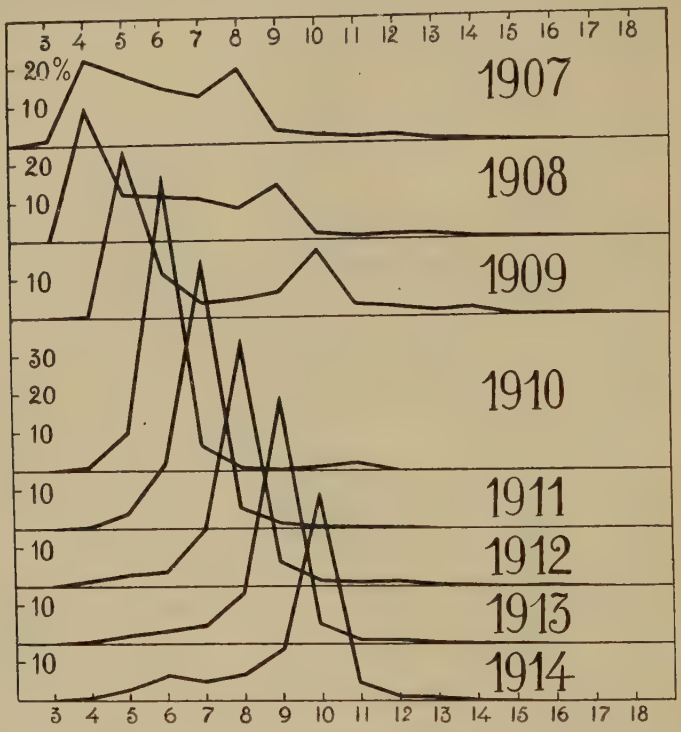

Fig. 5. Composition in point of age of spring herring for the years 1907—1914; average of all samples examined in each year. For 1914 only samples from February included.

years exceeds all the other year-classes, culminating in 1910 with 77.3 per cent and sinking in 1914 to fifty odd. There seems thus to be a distinct decrease, although the year-class is still very numerously represented".

In the administrative report for the year 1919 Mr. Lea describes the continuation of these investigations. Figure 6 is a reproduction of his description of the age composition during the whole series of years from 1907 to 1919. For the years 1914 to 1919 Mr. Lea has introduced a new way of treatment of the material, which also takes into account "the quantities of herrings represented by the investigated samples". We see from this figure the history of the year-class 1904 from the age

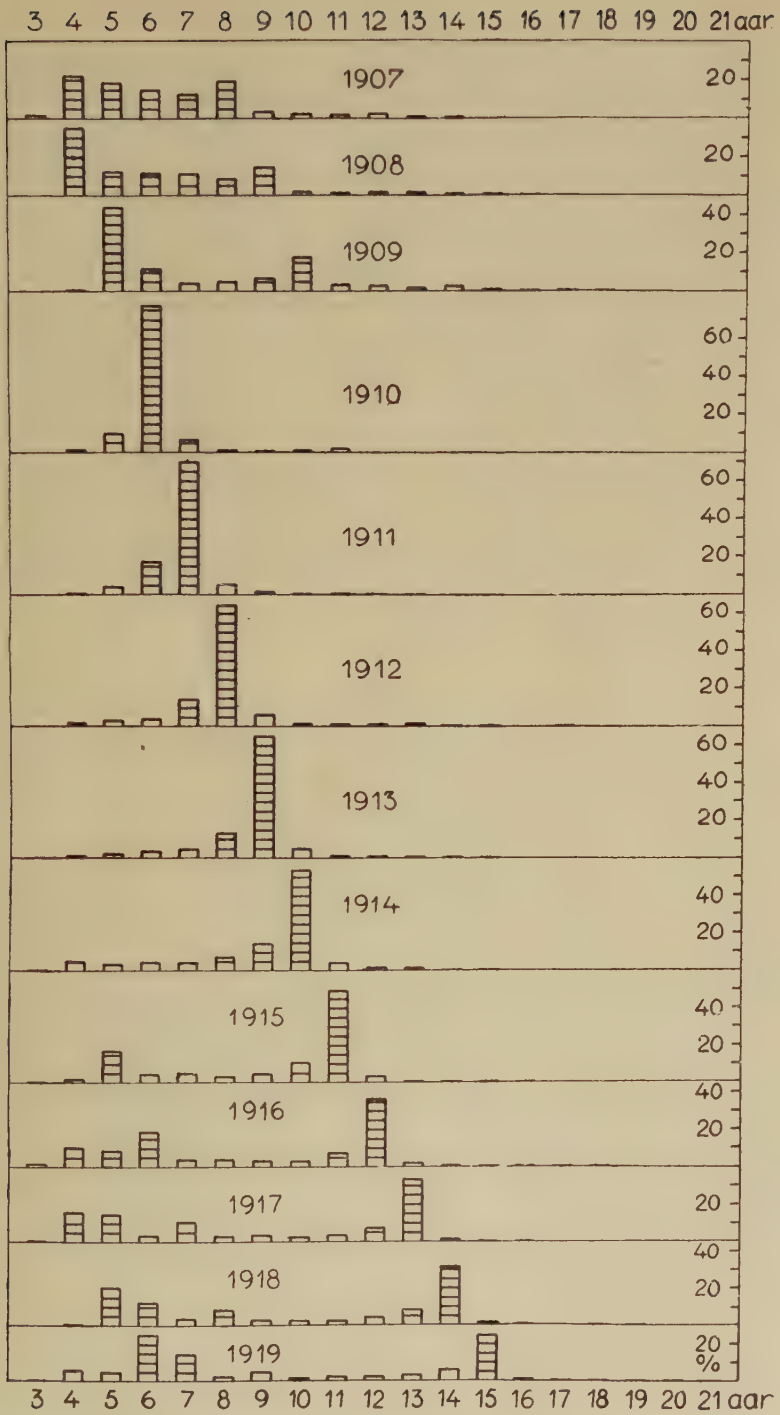

Fig. 6. For explanation see text.

of three to the age of fifteen years, and the enormous importance this one year-class played in the catches during this long period. We also note the enormous difference between the different year-classes, the year-class 1913 being the next fairly rich class In the year 1919, the year-class 1904, then 15 years of age, was still as numerous as the next rich year-class six years of age.

Mr. Lea has during the past years made several observations of importance as to the "immigration" of new young year-classes into the stock of the spawning shoals. The appearance of a new year-class in these shoals seems to be characterized by an arrival late in the season, which may complicate the picture of the composition of the spawning shoals. The complete understanding of the population may therefore need an extended investigation of all the different biological groups of the stock, and especially of the emigrations and immigrations from the one group to the other which take place during each year. The extensive and no doubt very interesting material collected is not yet available for a study of such occurrences.

Fluctuations in the cod fisheries of Norway.

The Norwegian fishery authorities have for a long series of years endeavoured to calculate the average weight of the Lofoten spawning cod (skrei) and I have combined the figures given by them (for average gutted weight) for the years 1882—1912 in figure 7. It will be noted that the line joining the different averages presents a wavy appearance. The years 1894, 1895 and 1896 lie in a deep hollow. Then follow a rise until 1899, a sharp fall to 1903 and 1904 with an equally steep rise to 1909, and finally a decrease towards 1912.

In my paper (Fluctuations 1914) I ventured to suggest this explanation of the events: "The periods of renewal of the shoals through new and young rich year-classes are distinguished by a decrease in the average size. When the immigration to the shoals of young fish is slight, the average size increases with the growth of the individuals. There will thus arise a fluctuation in the average size of the individuals of the spawning population, with periods of increase and of decrease.

I shall in the following try to indicate what light may be thrown upon this hypothesis by the material available.

My investigations of the stock of cod started in the year 1901, and were continued at intervals until the summer of 1913. Mr. Oscar Sund has later continued this work during the period 1916 to 1925. In figure 8 are given some curves from my measurements of the line-caught fish

during the years in which I visited Finmarken from 1901 -1913. The dotted vertical line is meant to indicate the dividing limit between the young immature fish and the "skrei".

In the year 1901, the bulk of the Finmarken fish belonged to the group of immature cod, mostly 50 -65 cm. in length. The age of these fish should, according to later age determinations, have been about 5 and 6 years i. e. of the year classes 1905 to 1907. Trawling experiments with fine-meshed trawl in the Varanger fjord produced a material showing

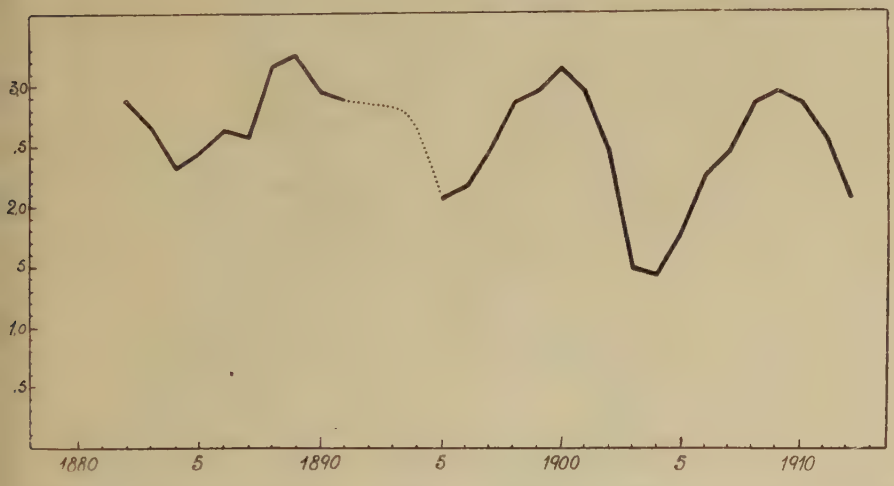

Fig. 7. Curve showing average weight of Lofoten skrei for the years 1882—1912, from statements of the Fishery inspectors, 3,0 = 3 kilos gutted weight.

a marked maximum of fish around the group 45 49, or 4 year old fish of the year-class 1907. There were then at least three year-classes, and especially that of 1907 of young fish and the curve (fig. 8) shows that very few big cod were present.

A comparison between the curves for 1901 and 1902 shows an increase in the size of the young fish and an increase in the number of small young mature fish. This immigration of small fish into the biological group of mature fish continued in the year 1903, when I had the opportunity to investigate the spawning shoals on the northern banks off Tromsø and Lofoten. The state of affairs in that year was perhaps the most remarkable ever recorded in the history of the Norwegian fisheries, and the most miserable of all years for the fishermen. The fish were smaller than ever observed before, no less than 46.8 per cent. of the fish being under 65 cm., the average percentage of the undersized fish for all the years from which we have measurements being 9.8. Also,

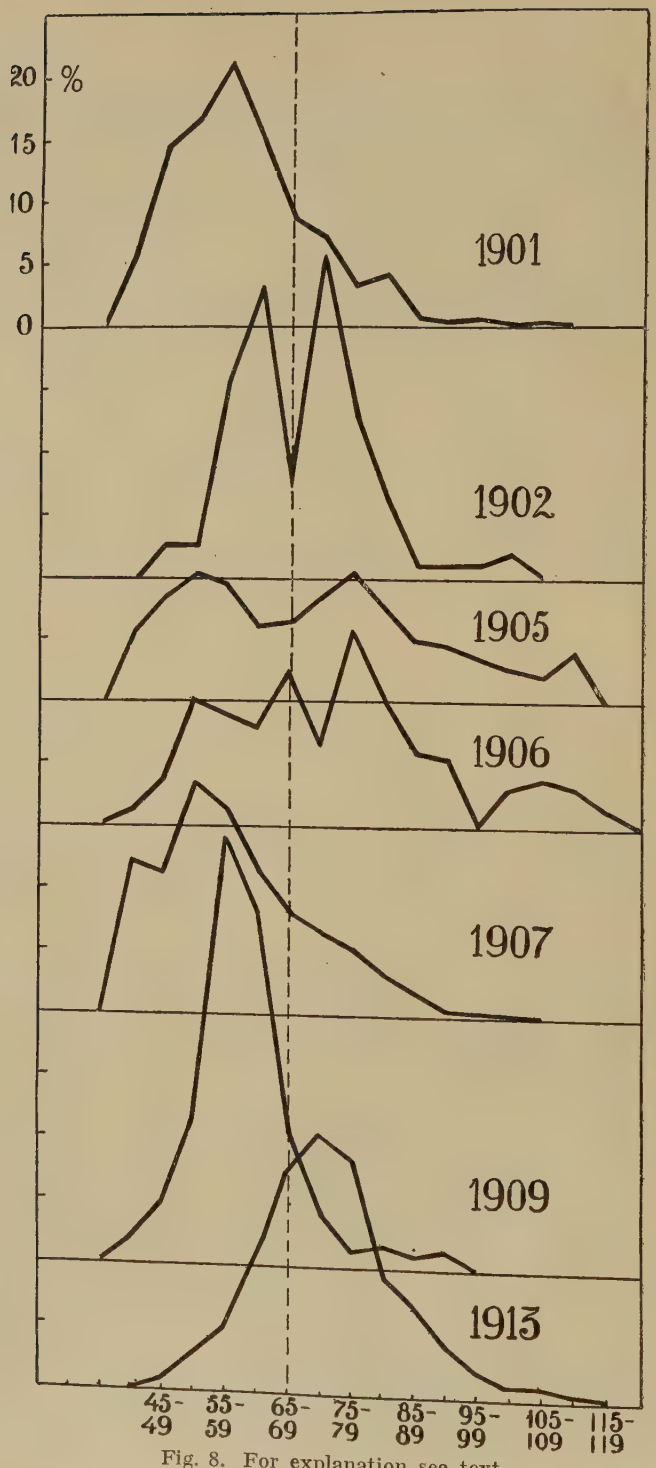

Fig. 8. For explanation see text.

the average size of the whole sample was only 66.1, the normal average for skrei being 76.4.

If we now consider the curve in figure 7, we shall be able to understand the sharp fall in the average size of the skrei during the years 1900—1903. During these years, the mixture of young and old fish in Finmarken showed an enormous preponderance of small fish, which gradually immigrated into the shoals of the skrei. The average size of the spawning shoals therefore fell off to about 1.5 kilo (gutted weight).

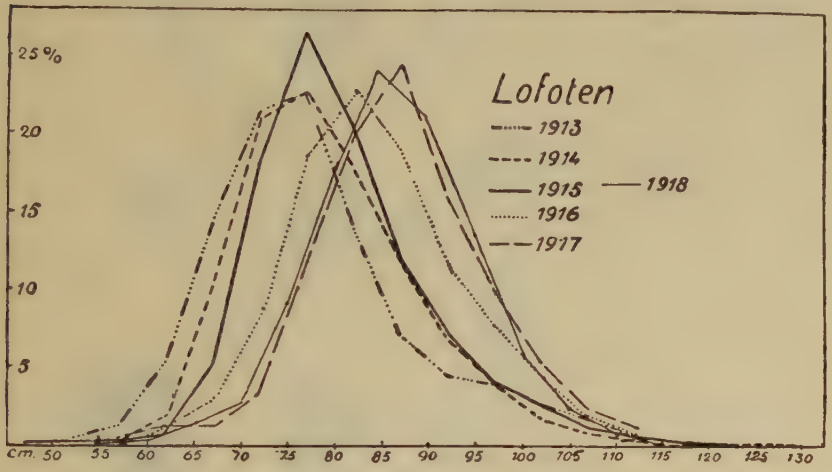

Fig. 9. For explanation see text.

During the following years the number of young fish was not very great in the Finmarken fisheries. From figure 8 we see in the year 1905 some contribution of the sizes 45—55 cm., or fish about 4—5 years, perhaps mostly 5 years old (i. e. of the year class 1900), but not before 1907 is there a marked increase of young fish. Corresponding to this, the curve in figure 7 shows a rapid increase in the average weight of the skrei during the years 1904 to 1910, the weight increasing from 1.5 to 3 kilos pr. fish.

In the years 1905 and 1907, I made some trawling experiments with a fine-meshed trawl, and the material thus collected was used for age determinations. In 1905, 64 per cent. of the fish taken in this trawl were between 15 and 19 cm. long and $1^1/_2$ years old. In 1907, similar trawling catches showed 55 per cent. of three-year old cod. In both cases, the fish belonged to the 1904 year-class. Among the catches of the fishermen, however, the 1904 fish — in the year 1907 — only amounted to some 6.9 per cent. They were still too small for the long lines of the fishermen. The young fish represented in the curve (figure 8) for 1907

Fig. 10. Number (stk.) of cod caught in different parts of Norway in each of 5 selected years. Figure prepared by Mr. THOR IVERSEN.

therefore mostly belonged to the older year-classes, but in 1909 the situation changed, the enormous number of young fish for the far greater part belonging to the 1904 year-class. In the years from 1910 onwards, we then see the enormous influence of the rich year-class in the Finmarken fishing and also in the skrei fisheries. We have during these years an increasing average size of the fish in Finmarken, until all fish there, as in 1913, practically consisted of big fish of exactly the same size as

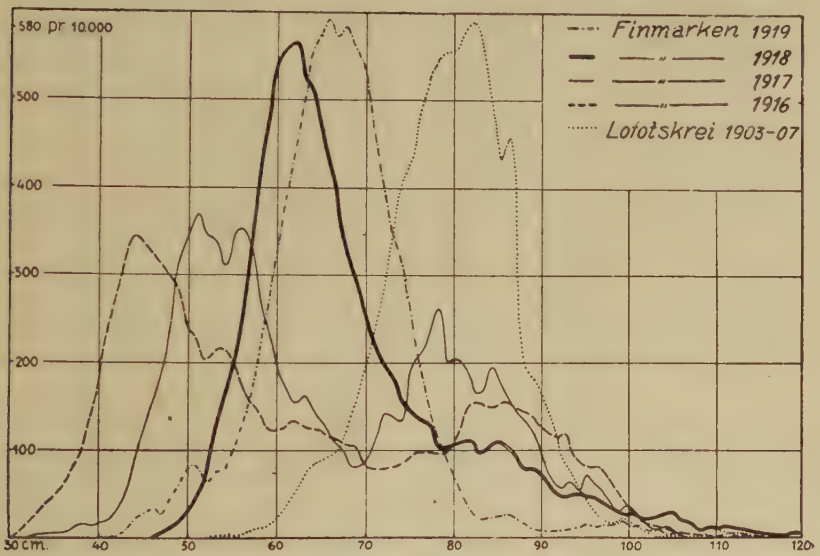

Fig. 11. For explanation see text.

the skrei, whilst the small additions of young fish belonging to year-classes following the one from 1904 could not even change the picture of the curves. As regards skrei, the years 1910 and onwards showed a marked decrease in the size (see fig. 7) as the immigration of the 1904-group increased in percentage of the whole population. In 1913, the 1904-group made some fifty percent of the skrei group, and the skrei had an average weight of about 2 kilos per fish. Mr. Sund's measurements of the skrei of the Lofoten fishing have now shown how a constant increase of the sizes took place during the period 1913—1918. This is very well illustrated by figure 9. The average weight of the fish rose during this period to over 3 kilos per fish.

A very good illustration of the enormous influence of these biological factors on the fisheries is given in figure 10 which was worked out by Mr. Thor Iversen. We notice from this figure the increase in the yields of the Finmarken fishing during the years 1904—1912, an increase in

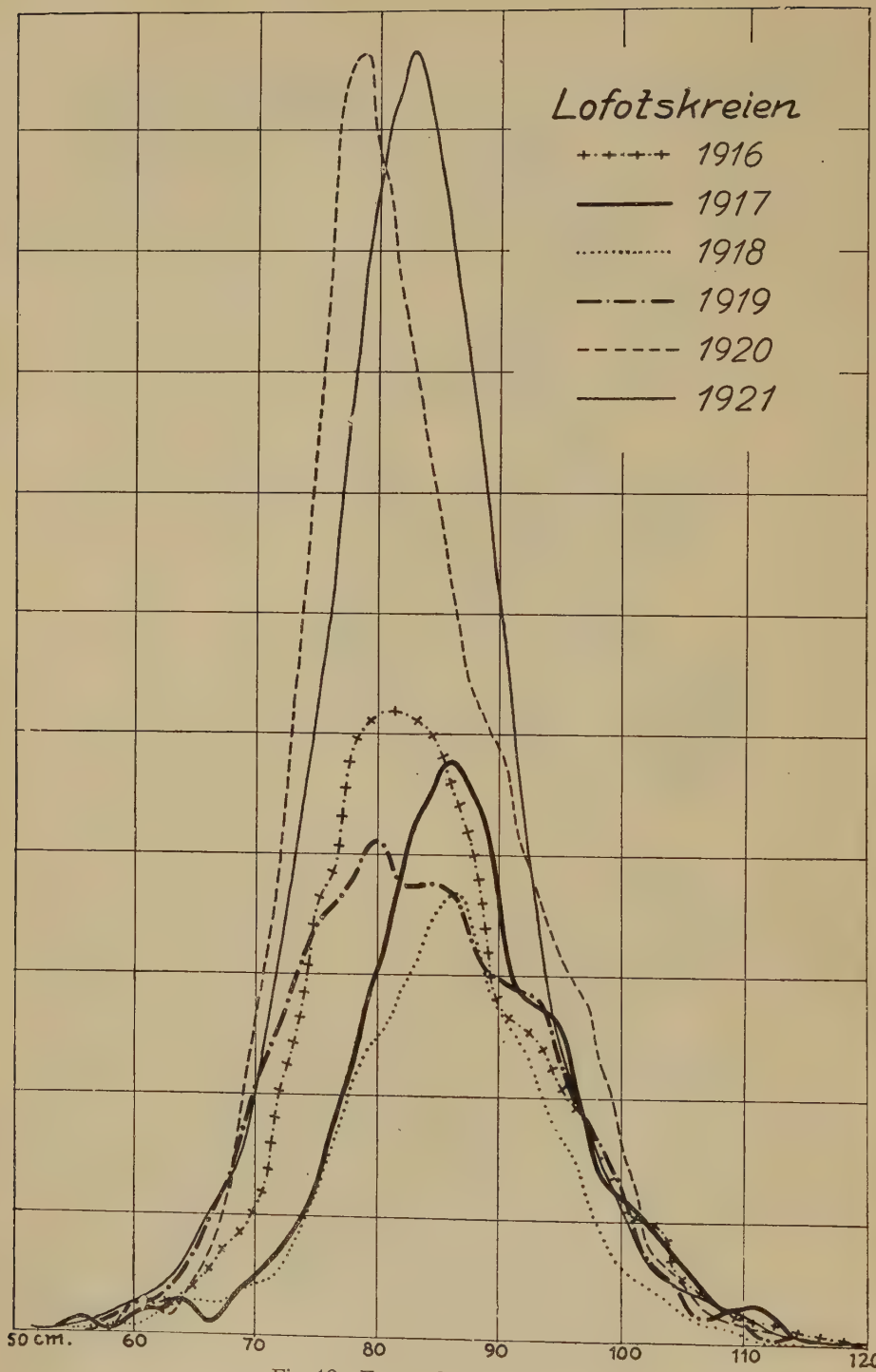

Fig. 12. For explanation see text.

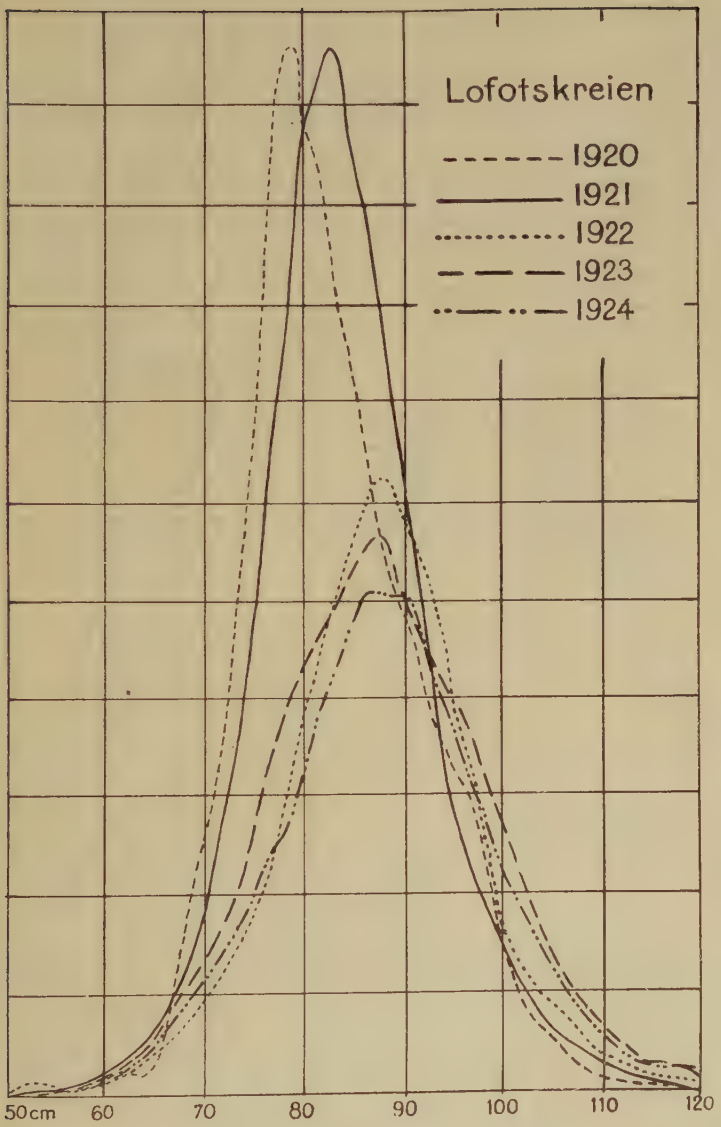

Fig. 13. For explanation see text.

the skrei fishing off Lofoten and Møre in 1912 and 1915, and a rapid decrease to 1918, with the exception of the Finmarken fishing.

Figure 11 then illustrates an important development within the Finmarken district of a new stock of young fish during the years 1916—1919. We find in this figure 5 curves, of which the one farthest to the right gives the average size of the skrei during the years 1903—1907.

All the other curves represent the Finmarken fish. It is characteristic of these that the component of young individuals grows larger from year to year, while the component of large fish becomes less important during the period. This is a typical curve from a situation in which there is a coming new rich year-class. From the sizes of the young fish, as well as from Mr. SUND's age determinations, it is clear that it belonged to the year 1912. In 1919, this fish was 7 years old, and it might therefore be expected that in 1920, it would play a part in the skrei fisheries. This was also clearly understood and predicted by Mr. SUND in his report for 1919.

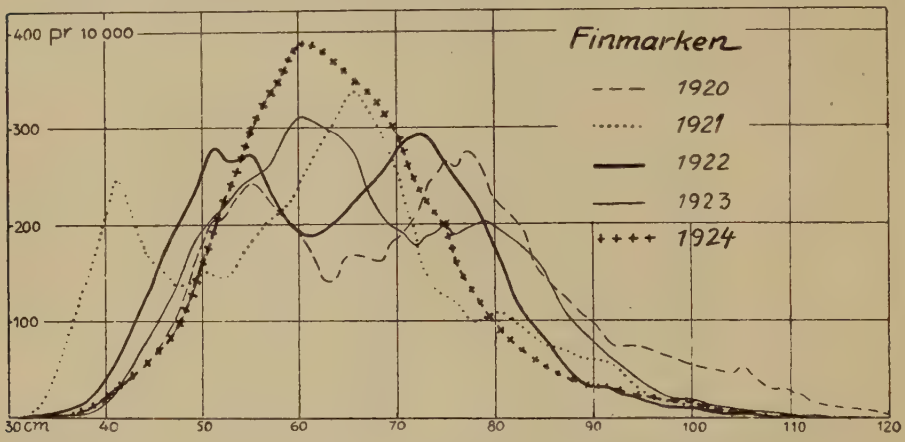

Fig. 14. Composition in point of size of the Finmarken fish in different years.

In the report for the year 1921, Mr. SUND introduced a great improvement in the treatment of the fish measurement. For the years 1916—1921 (see figure 12) all the measurements from the different years were multiplied by the figure of the number of fish caught per fisherman per fishing day in the particular year. By comparing the different curves in the years, we get a picture of a rather small and old population of spawning fish, increasing in average size from 1916 to 1917, decreasing in number in 1918, then decreasing in average size in 1919 (through a small new contingent of 7 year old fish) and then greatly increasing in number and decreasing in size from 1919 to 1920. All these events become quite clear and understandable from the knowledge of the coming new year-class of 1912.

In the period 1920—1924 we have again the picture of a population of skrei consisting of individuals increasing in length from year to year. This is illustrated by figure 13.

During this period of years 1920—1924, in which the picture of the skrei population gives us the impression of a population without any

renewal from younger year-classes, no fewer than three new year-classes were developing in the great nurseries of the Barentz Sea. These are the year-classes 1915, 1917 and 1919. The development of the two first of these, 1915 and 1917, may be seen from figure 14. In 1920, we have a maximum of 5 year old cod 50—60 cm. long, in 1921 a maximum of 4 year old fish of 45 cm. length; in 1922, this group (the 1917 year-class), exhibits the average size of the 5-year old fish. In 1923, this group ap-

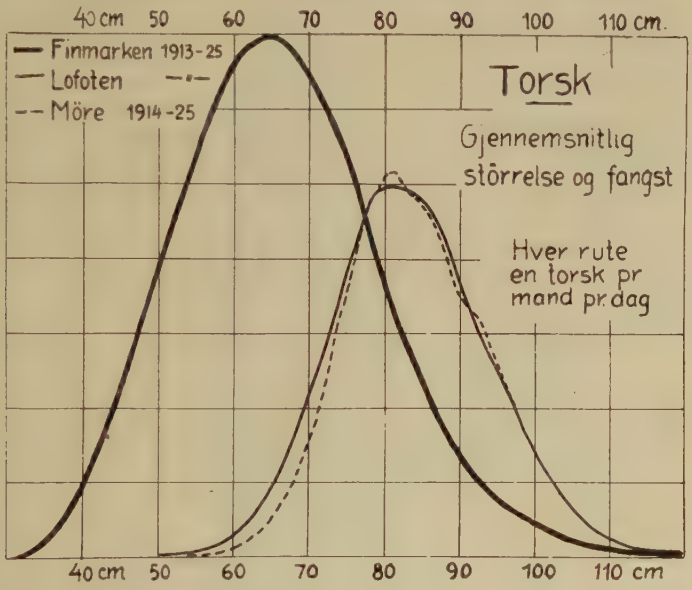

Fig. 15 Cod. Average of size and catch. Each square denotes one cod per man per day.

proaches the size of the younger skrei, and in 1924, there seems to be no further growth; a phenomenon often occurring when there is an emigration of the largest individuals of a year-class into another biological group (in this case into the skrei group). Still another year-class was developing in the last years, but not represented in the catches of the fishermen, viz: the year-class 1919, which in any case should have been noticed in the year 1924. My information of the existence of this group is based on data placed at my disposal by Mr. Sund for the skrei fishing of 1925. I shall not, however, go into further details, but will conclude this review of the history of the fluctuations in the stock of cod during the last 25 years by a description of the method which Mr. Sund, on the basis of the last years' experience, recommends for the statistical treatment of the material of measurements collected from year to year.

With the assistance of the fishery police at the Lofoten fishery, it

was ascertained that every fisherman present on the 15th of March had participated in two-thirds of the known number of days on which weather permitted fishing to be carried out. From this information, the measurements for the years 1913—1925 could be weighted by the corresponding figure for output per man per day. All the information thus obtained could then be used for the construction of the average size curve for the Lofoten and for the Finmarken fishing. These curves are represented in figure 15, where each square denotes one cod per man per day.

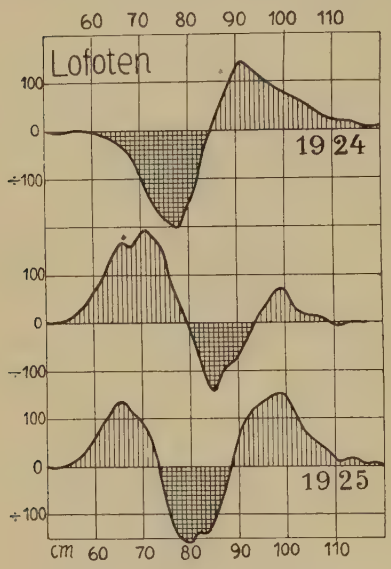

Fig. 16. For explanation see text.

On the basis on this curve for the averages for the whole period of years, special curves for each year may be constructed, and the curves for the different years may be compared with each other. As an example of the method which Mr. Sund recommends for such comparison, I give his figures for the Lofoten and Finmarken fishing for the years 1924 and 1925 (See figures 16 and 17). We have here in each case two curves, one for 1924, one for 1925, giving the differences between the general average curves (fig. 14) and the curves of measurements for each of the two years. In the middle, between the two curves, there is a curve representing the differences between the two years themselves. Mr. Sund expresses his method in the following way:

If x represents the average number of fish for any centimeter group (figure 14) b the corresponding number for 1925 and a for 1924, the three curves (of figures 16 and 17) are constructed in this way:

(1) represents $a—x$.
(2) — $b—a$.
(3) — $b—x$.

Instead of the expression $(a—x)$ or $(b—x)$ Mr. Sund has also found it very useful to construct curves for the expressions

$$\frac{a}{x} \quad \frac{b}{x} \quad \ldots\ldots \text{ and } \frac{b—a}{x}$$

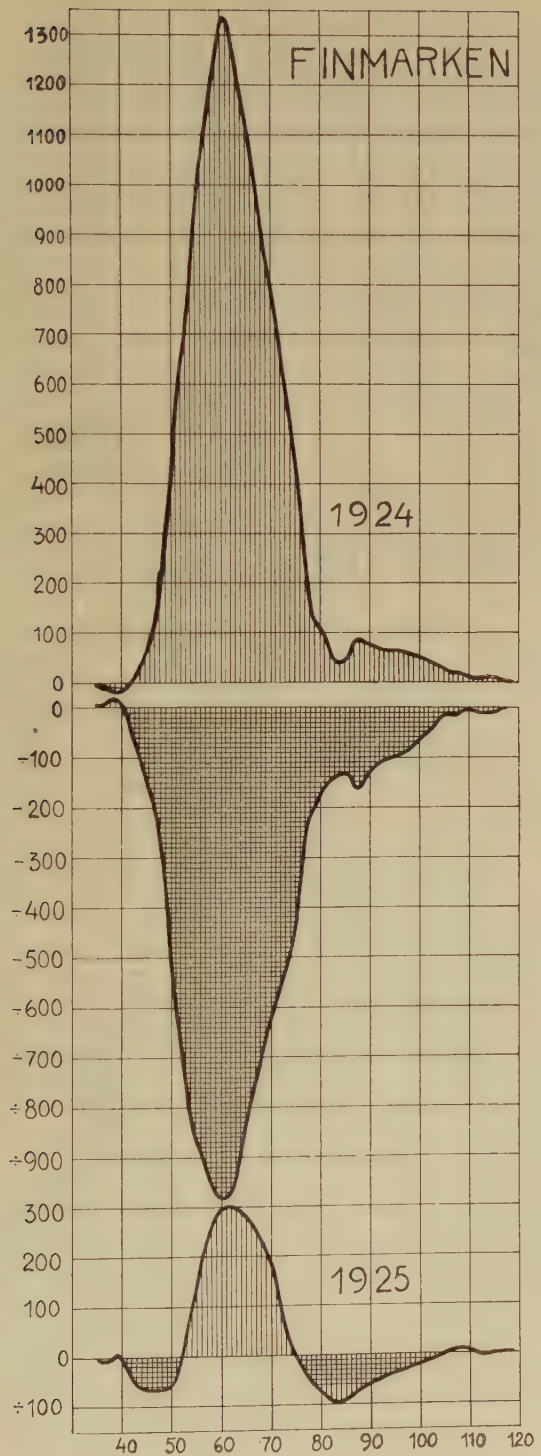

Fig. 17. For explanation see text.

The purpose of this method is to study the alterations within the stock in point of size, and thereby, indirectly, of age. In a similar way, different seasons, different months, different catches may be compared. Returning to figure 16 for the Lofoten fishing we see that the year 1924 was characterised by a deficit from the average of small and a surplus of very large fish, while the year 1925 had a surplus of very small, a deficit of medium and a surplus of very large fish. The curve of differences between the two years gives directly the explanation of this by demonstrating the immigration of young fish belonging to the year-classes 1915, 1917 and 1919 into the stock of the spawning cod. This emigration from the Finmarken population is demonstrated by the figure 17.

Fluctuations in other populations.

The appearance of the enormously rich year-class 1904 in the stock of Norwegian herrings and cod at first gave rise to the idea, that the year 1904 was especially favourable for the production of all kinds of fish in Northern waters. Some material of measurements of haddock collected by English and German research steamers during the years 1903—1906, which were placed at my disposal and worked up by Helland-Hansen, also suggested the probability that the 1904-class had played an important part in the population of haddocks in the North Sea.

Investigations which I carried out in Canadian waters[1]) during the winter 1914—1915, gave the surprising result that the majority of mature Newfoundland herrings belonged to the year-class 1904. The curves of age composition in the samples in fact closely resembled those given here in figure 4, page 13.

Other evidence, however, very soon revealed the fact that the experience of the year-class 1904 had no such general bearing. Investigations of herrings from the North Sea belonging to populations quite different and separate from that of Norwegian waters, demonstrated a totally different composition with regard to year-classes[2]). Similarly, samples of herrings from the coast of Nova Scotia, even those from the southern shores of the Gulf of St. Lawrence, were very different with regard to their mixture of year-classes from those of the Newfoundland waters.

It had therefore become quite evident, that the vital statistics of fish populations would have to be studied separately for each geographical area.

[1]) Investigations into the Natural History of the Herring in the Atlantic Waters of Canada. Suppt. 5th Ann. Rep. of Naval Service Ottawa 1915.

[2]) See my paper on Fluctuations, Chapter II.

The experience of later years has further shown, that the rich year-classes may not always be the same for all species of fish, even within the same geographical area. The year-class 1904 was rich in the stock of herrings as well as in the stock of cod. The next rich year-class in the stock of cod was, as we have seen, above that of 1912, while the year 1913 was the first year after 1904 producing a rich year-class of herrings.

We arrive therefore at the important conclusion, that the study of vital statistics of any population of fish must be based on empirical evidence, collected by special investigations separate for each geographical area, and within this area for each species. This experience corroborates all the important results gained by the study of racial characters and marking experiments, and demonstrates once more, as I have emphasized above, that vital statistics must be preceded by a thorough understanding of the life history of the fish, as well as by special knowledge of the geographical limits of the distribution or migrations of the population in question.

It is evident that such investigations are very much facilitated in waters where the fish appears on somewhat small, sharply defined banks and in shoals, consisting only, or for practical purposes only, of one biological group of the species, as for instance of spawning cod. The gear of the fishermen will then be adapted to the catch of such fish only, and the catch will be directly suitable for the selection of samples representative of the shoal. Investigations of a very large number of such samples have abundantly proved that even very small samples, of some hundred individuals or less, may show exactly the same percentual distribution of the year-classes as the collected samples of ten thousands of individuals in all will show. See for comparison figure 4 above.

It follows from this that the investigation of the vital statistics of the fish populations will be much easier in such waters as the Norwegian, those of Iceland, the Faeroes, of Newfoundland, than in more extended waters like the North Sea, where the topographical features of the depths of the bottom are not so distinctly marked, where a great mass of fish of many species and a great number of year-classes of many species are all caught together in the same gear.

If the statistical treatment of the material collected from catches of this kind is difficult in itself, the difficulties will be overwhelming if we try to analyse the data collected after such material has been grouped together from purely commercial and non-biological points of view, in groups such as small, medium or large, of fishes such as haddock or cod.

The investigators of the fisheries of the North Sea have tried in different ways to analyse such material by taking enormous masses of data into their calculations, but even these great efforts have proved the many difficulties of the task. We find, therefore, that the investigators of the problem of fluctuations in the North Sea express themselves with great reserve. Thus RUSSELL, in his study of the fluctuations of the haddock[1]). "In general, it may be said that the density of Small is high when its percentage is high. Thus it is high in the areas south of 56° in 1906, and in the areas to the north in 1907—08. It is to be noticed, however, that especially in the most southerly areas, the density of Large was particularly high in 1906. There are indications in a certain number of areas that a maximum density of Small is followed at an interval of two or three years by a maximum in Large."

With regard to the cod, RUSSELL states as follows:[2]) "In the North Sea, a definite increase in abundance was shown in 1909, continued in 1910, and followed by a slight and gradual fall in 1913. This increase in 1909 was mainly due to Small cod, followed by a maximum in Medium in 1910 and in Large 1913. The "good year" for production of eggs and larvae in the North Sea was not the same as the "good year" in Norwegian waters (1904), but at least two years later". It has, for a long time, been clearly understood by scientific investigators of the North Sea, that the study of the fluctuations must not in the first instance be based on such statistics. Thus RUSSELL (in his paper on the cod statistics page 44) says as follows: "It will be seen then, that the classification into groups, according to density, arrived at in the preceding section, has what one might describe as a statistical value only, and that it requires to be supplemented and interpreted by the study from a biological point of the movements of the cod, particularly of the large cod".

An energetic effort has therefore been made to elucidate the life history of the most important fish in the North Sea, by experimental trawlings from the research steamers, by marking experiments, and by the study of the distribution of the floating eggs and larvae.

By means of this work, an attempt has been made to determine the spawning areas of the principal fish, plaice, herring, cod, haddock, to define the spawning migrations, the nurseries where the young fish develop, etc. It is to be hoped that it may in this way be possible to

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[1]) E. S. RUSSELL: Report on market measurements in relation to the English haddock fishery during the years 1909—1911. Ministry of Agric. and Fisheries. Fishery Investigations. Series II Vol. 1. 1914.

[2]) Report on market measurements in relation to the English cod fishery. M. A. F. Fishery Investigations. Series II Vol. V no. 1. 1922.

find the general laws for the appearance of biological groups, and thus be possible to find a practical way of collecting representative samples, which will allow the investigator with reasonable effort, to follow the fluctuations from year to year.

In English scientific literature, we find several statements showing that this may be possible also in the North Sea. Russell summarized his studies of the distribution of the Large cod in this way: "On the whole, then, the spawning areas indicated by the study of the English commercial statistics correspond very well with those deduced from planktonic investigations, except that the apparently very important spawning grounds between the Dogger and the English coast have not yet been shown to be specially rich in eggs and larvae. But they have not yet been intensively studied from this point of view. It may be taken as firmly established that the Large cod seek certain areas in the west and central parts of the North Sea in spring for the purpose of spawning; that they there assemble in considerable quantities and form the objective of an intensive fishery".

"It will be seen that, as in haddock, there is a definite indication that cod tend to segregate in shoals of roughly the same lengths. It is probable that in the case of the shoals of smaller fish these are fish of the same age".

Very important and interesting investigations have been made by Mr. Harold Thompson[1]) with the purpose of determining the quantitative fluctuation in the appearance of fish in their first year of existence. The records of the last twenty years, says Mr. Thompson, show that very good years for the survival of haddock larvae occur at greater or less intervals, and 1904, 1909, 1913, 1914, 1916 and 1920 were obviously such. The remaining ten years of the period were moderate or average years.

The study of the effect on the stock of the spawning in the year 1920 has demonstrated that seven-tenths of the market supplies in 1923 belonged to the year-class 1920.

Still more interesting is the intensive study of the result of the spawning of the haddock 1923. "There made its appearance felt in the latter half of 1923 a shoal of baby haddock of most exceptional numerical proportions. The western portion of the North Sea was completely colonised by these fish and a strong easterly extension included the Great Fisher Bank in its distribution". Mr. Thompson was able to illustrate

[1]) Harold Thompson: Haddock Biology II. Frequency and Distribution of the age classes in 1923. Scientific Investigations, Fishery Board for Scotland. Edinburgh 1924.

on excellent charts the spawning grounds as well as the area of distribution of the young haddock of the first year, and on these charts to estimate the average number which could be caught per 10 hours' fishing with a fine-meshed trawl in the different parts of the area.

This work is not only of great scientific interest, but it has an immediate practical importance, giving valuable information several years in advance of the possibilities for the fishing in the years to come. It seems to open up the possibility of keeping the stock of fish in the North Sea under the same control from one year to another as has been possible in other areas, and especially in the waters off the Norwegian coast.

For the practical application of such knowledge, however, it is of great importance to remember that the ideal of such work is the consideration of the entire population within a certain geographical area. The distribution of the population varies according to the seasons, and changes of the hydrographical conditions within the area. A study which limits itself to a smaller part of that area may miss the point of the importance of the fluctuations of the magnitude of the stock, and a fishery limited to a smaller part of the area may fail, while at the same time, vast masses of fish may be present in other parts of the area. For those interested in the more limited field only, the influence of fluctuations in magnitude of the stock may therefore seem of smaller importance than the migrations or fluctuations in the distribution of the individuals of the stock. A complete valuation of the fluctuations of the stock therefore demands practical fishing, or extensive fishing experiments all over the geographical area of the population of a certain species.

Origin of the fluctuations in renewal of the stock.

In my paper on fluctuations (1914) I advanced the following theory: "The rich year-classes appear to make their influence felt when still quite young; in other words, the numerical value of a year-class is apparently determined at a very early stage, and continues in approximately the same relation to that of other year-classes throughout the life of the individuals". "The above statement, despite the general terms in which I have, for the sake of convenience, preferred to formulate it here, is naturally only intended to apply to the data and material dealt with in the present work, without prejudice as to the possibility of great reductions taking place in the numerical value of the year-classes at later periods of life. All that it is desired to assert is that the observations here recorded distinctly point to the conclusion that the fluctuations

noted in the stock have their origin in certain conditions prevailing at a very early period in the life of the fish".

The 1904 year-class of the cod was found to be prominent in trawling experiments off Finmarken in 1905 and 1907, the 1912 year-class of cod in trawling experiments 1913, and the 1913 year-class of herring attracted attention already in the catches of small herrings in the autumn of 1913. Similarly, Mr. THOMPSON has demonstrated the existence of a new rich year-class of haddocks in the autumn of the first year of the life of the fish. The experience gained of the 1904 year-class in the cod in Norwegian waters further warranted the conclusion, that a new and rich year-class may develop in a year remarkable for the smallest quantity of roe observed during the Lofoten fishery. This being so, it was "difficult to avoid the conclusion, that the actual quantity of eggs spawned is not a factor in itself sufficient to determine the numerical value of a year-class". The same observations have lately been made by Mr. THOMPSON, who draws attention to the fact that the spawning shoals which produced the successful brood of haddocks in the year 1923 "were smaller than in the two previous unsuccessful years".

As factors, or rather events which might be expected to determine the numerical value of a new year-class, I drew attention to the following two possibilities:

1) That those individuals which at the very moment of their being hatched did not succeed in finding the very special food they wanted would die from hunger. That in other words the origin of a rich year-class would require the contemporary hatching of the eggs and the development of the special sort of plants or nauplii which the newly hatched larva needed for its nourishment.
2) That the young larvae might be carried far away out over the great depths of the Norwegian Sea, where they would not be able to return and reach the bottom on the Continental shelf before the plankton in the waters died out during the autumn months of their first year of life.

I had myself to leave these possibilities and their respective influence, if any, on the formation of the stock undecided, and the final decision in this matter may still be said to be open for discussion.

Interesting contributions to such a discussion have, however, lately been given by Professor H. H. GRAN[1]) and Mr. OSCAR SUND[2]).

[1]) H. H. GRAN: Samtiden. Oslo 1923.

[2]) OSCAR SUND: Aarsberetning for Norges Fiskerier 1923 and letter to Nature 2nd February 1924.

Gran, in a short article, referred to extensive investigations, the detailed data of which have not yet been published, in which he demonstrates the great importance which the fresh water from the land through rivers and (in Norwegian waters) the melting of the snow, must have for the development of the plankton through the salts, especially nitrates and phosphates, which the fresh water adds to the sea water. He then emphasizes that the variations in the outflow of water from the land may strongly influence both those groups of events which I suggested as influencing the origin of a rich new year-class. If the production of the

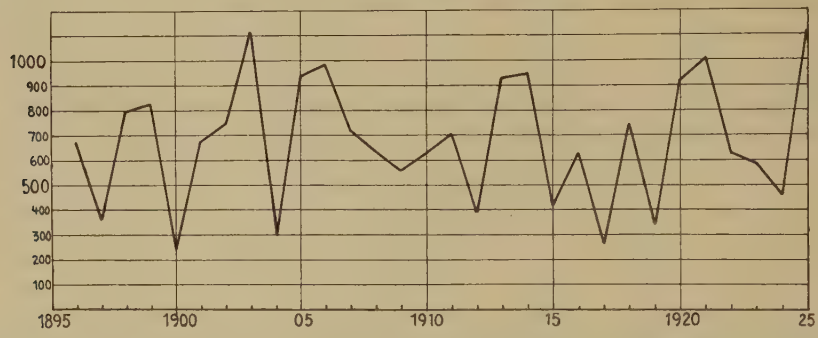

Fig. 18. Curve for rainfall (rain and snow) in districts of Norwegian West Coast during the years 1895—1925.

plankton is the decisive factor, he says, we should expect that heavy rain or snow would give a new rich year-class; if the contrary, the off-shore currents of coast water would carry the larvae out into the sea, and such events would have the importance we should expect, viz. that a dry winter would appear to be the best.

From this last point of view, Mr. Oscar Sund has examined the weather reports for the districts of the West coast of Norway for the four months December to March through the years 1895 to 1925. The results of this examination are given in figure 18. Mr. Sund draws attention to the fact that the following years have had the smallest rainfall: 1897, 1900, 1904, 1912, 1915, 1917, 1919 and 1924 and that these very years have produced the rich year-classes in the population of the Norwegian cod. One must admit that the agreement between these two series of events is very remarkable, although the magnitude of the so-called rich year-classes is neither equally well established nor of the same order in all the cases within the series. It should be remembered that my first investigations for the years 1897 and 1900 were based on rather small material, partly because I did not at that time understand the importance of fluctuations in the year-classes, and partly because

the means at my disposal then were very small. None of the year-classes may have been of the magnitude of that of 1904, but an exact comparison is not possible. Nevertheless, the agreement must be considered as most interesting. Another difficulty is, that I found the young cod larvae in 1900 drifting over 120 miles away from the coast, and this year-class has later on been claimed as being one of the rich year-classes.

Mr. Sund does not put forward any hypothesis with regard to the mechanism at work at the time when the magnitude of the year-class is determined. And it seems to me for several reasons desirable not to attack this important problem from any preconceived standpoint. On the contrary, the simultaneous investigation of meteorology, hydrography and biology seems the only way to a deeper understanding of the conditions in which the destiny of the spawned ova is being decided.

In such work, we should remember that the rich year-classes were different for the population of the cod and for that of the herring, even in the Norwegian waters, and that circumstances in the North Sea were to some extent different from those of the Norwegian Sea. One might perhaps expect that the conditions which decide the fate of the larvae may in all cases be of a similar general character, but in each case subject to modifications, which will also modify the effect of their influence. The time of hatching may differ for the different species, and for the same species in different waters. The development of the plants and animals on which the larvae prey may differ independently from the development of the larvae. The currents of the waters in which the larvae and the plankton are suspended may alter from time to time during the spawning period and after. Nevertheless, it may be possible to combine all the different events into one general rule, as soon as a series of incidents have been subjected to thorough investigation, and as soon as each case has been clearly understood. The interesting investigations of Mr. Davis[1]) on the fluctuations in the Benthos of the Dogger Bank may serve as an example of investigations of this kind.

For the coming season, investigations are planned for such studies in the Norwegian Sea (the "North Eastern area") two different series, one off the coast of Møre, the other off the Lofoten islands for the purpose of examining, at short intervals all through the spring, the water layers (salt, oxygen, nitrates) the plants, copepods and fish larvae in sections from the shore across the coastal waters. I have accepted the kind invitation of the Editor of this journal to write this article in the hope

[1]) F. M. Davis: Quantitative studies on the Fauna of the Sea Bottom. M. A. F. Fishery Investigations Series II, Vol. VI no. 2 1923 and Vol. VIII no. 4. 1925.

that it may contribute to an increased interest in co-operation with a view to the solution of the questions discussed in the article.

Résumé.

Dans l'article qui précède, j'ai parlé de quelques-uns des exemples que rapporte la littérature actuelle, établissant d'après les expériences acquises, comment les fluctuations de la densité des différentes classes annuelles d'un poisson déterminé, correspondent aux fluctuations observées par rapport au rendement de la pêche professionnelle. J'ai pris comme point de départ, les expériences qui ont été mentionnées dans un rapport précédent (Fluctuations 1914), en ce que j'ai essayé de démontrer d'abord, comment les conditions qui s'y trouvaient exposées au sujet de la population des morues et des harengs dans les eaux norvégiennes, se sont modifiées pendant les années écoulées depuis lors.

Il s'est montré à l'étude des bancs de harengs pendant le frai, sur la côte norvégienne, qu'une série d'échantillons recueillis sur le parcours de plusieurs centaines de lieues (fig. 3) — chaque échantlloni contenant quelques centaines d'individus — manifestaient les uns par rapport aux autres, la meilleure concordance (fig. 4) en ce qui concerne la représentation des classes annuelles dans ces échantillons et ce de manière à justifier l'espoir que l'on avait d'avoir obtenu ainsi des échantillons constituant une représentation vraie de la population poissonnière de ces parages. La répartition singulière de la densité des classes annuelles, celle d'une seule bonne année (1904) dont il est fait mention dans la publication de 1914 (fig.5), a été confirmée par les recherches faites depuis (fig.6) et poursuivies jusqu'à l'année 1919. Pour la pêche de la morue j'avais attiré l'attention en 1914 sur le fait que les données officielles, pour de nombreuses années, sur le poids du poisson à Lofoten, accusaient une suite de périodes de décroissance et d'accroissement du poids chez les bancs en frai (fig. 7). Ce phénomène s'explique par les fluctuations de la densité des classes annuelles en ce que, par l'apparition d'une nouvelle année riche, la population poissonnière est dotée de nombreux individus jeunes et petits, d'un faible poids, en raison de quoi il se produit pendant des années de ce genre, une réduction du poids moyen, tandis que ce poids augmente lorsque l'affluence de nouveaux individus est faible, c. à. d. lorsque les dernières classes annuelles sont pauvres. La preuve en est établie, dans le détail, par le fait qu'il y a eu un fléchissement pendant la période 1910—1913 où les individus de l'année 1904 apparaissaient dans les bancs en frai (fig. 8), tandis que, par la suite, il s'est produit une augmentation du poids moyen pendant les années 1913—1918,

période pendant laquelle il n'y a pas eu d'année riche (fig. 9). La figure 10 accuse des fluctuations sensibles dans le rendement des pêcheries de ces années, ce que l'on comprend en tenant compte des fluctuations précitées survenues, constatées par rapport à la densité poissonnière des différentes années. Il a apparu dans la période de 1919—1921 (figures 11 & 12) une nouvelle année riche, celle de 1912, qui eut pour effet de réduire les dimensions du poisson parsuite de l'apparition dans les bancs de nombreux jeunes individus. Les dimensions du poisson s'accrurent de nouveau au cours de la période de 1921—1924 pendant laquelle les bancs en frai n'avaient pas été augmentés par de nouvelles classes annuelles riches (fig. 13) et, enfin, il survint en 1925 une forte réduction du poids moyen par le fait que rien moins de 3 nouvelles classes annuelles, celles de 1915, 1917 & 1919 apparurent dans les bancs (figures 13—17).

Je cite des exemples démontrant que l'apparition des classes annuelles riches ne se produit pas suivant une loi déterminée, c. à. d. en ce sens que l'abondance se produirait, pendant une même année, pour toutes les espèces de poissons dans les mêmes parages ou même sur de vastes étendues de la mer. L'expérience a démontré, au contraire, que le cas est spécial pour chaque espèce de poisson en particulier dans une région déterminée et j'en conclus qu'il faut étudier à part chacune des espèces de poissons. Cette condition s'impose notamment du fait qu'il y a une différence entre les eaux norvégiennes et la Mer du Nord où des explorateurs britanniques, tels que par exemple, E. S. Russell et H. Thompson, ont démontré qu'il se produit d'importantes fluctuations dans la population des morues et des aiglefins.

Le fait qu'il est devenu possible de constater de bonne heure dans l'évolution de la vie du poisson — déjà à la première phase de sa vie au fond de la mer — l'apparition d'une nouvelle classe annuelle riche, présente une importance pratique. Cette possibilité à été établie aussi bien par mes recherches dans les eaux norvégiennes que par les chalutages effectués avec des filets à mailles finement serrées de Thompson dans la Mer du Nord. Il est devenu possible de prévoir ainsi, plusieurs années à l'avance les années riches en poissons.

A la fin de l'article, il est fait mention sommairement des différentes opinions émises en vue d'expliquer les conditions dont dépend une nouvelle classe annuelle riche. On est unanimement d'accord pour établir qu'il faut rechercher dans les débuts de l'évolution de la vie du poisson, le moment décisif et, conséquemment, il y a tout lieu de supposer qu'il doit en être de même pour toutes les espèces de poissons, bien que les résultats obtenus ne soient pas les mêmes pour toutes les différentes espèces pendant une même année. Nous savons, en effet, que les périodes

du frai et autres circonstances sont variables pour les différentes espèces de poissons, même dans les parages communs à ces espèces. Il est vraisemblable que dans les recherches futures, l'attention se portera sur deux questions, à savoir d'abord, s'il ya, ou non, les éléments de nutrition nécessaires et en quantité suffisante au moment de l'éclosion des larves de poisson et, ensuite, si la migration des larves, par les courants, les conduit — ou non — en des endroits favorables à leur croissance. J'ai recommandé que ces questions fussent portées sur le programme de travail de la co-opération internationale dans les pays de l'Europe du Nord et l'article en question a pour objectif essentiel l'importance d'une co-opération de ce genre.

The Relation between Cod-end Mesh and Size of Fish Caught.

Preliminary Experiments with the Trouser Trawl

by

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Little information appears to exist as to the relation between the size of the cod-end meshes of the otter trawl and the size of the fish which it captures. Mesh experiments with beam or otter trawls have been carried out in the past by Fulton[1]), Redeke[2]), Todd[3]), and others, and the problem of evolving a "savings trawl" has been tackled ingeniously by Ridderstad[4]), but the data recorded are not extensive and some are of doubtful applicability to modern conditions.

The question is however one of very special interest. It is undeniable that large quantities of undersized and unmarketable fish are daily destroyed in the course of trawling operations and it stands to reason that the size of mesh employed must have some effect upon the size of fish taken.

There is evidence that the tendency of late years, ever since the introduction of fine meshed nets for herring trawling about 1912 –14[5]), has been for the cod-end mesh to decrease. Todd, in

[1]) Fishery Board for Scotland, 12th Annual Report, Pt. III. pp. 302—12, 1894.

[2]) Verhandel. Rijksinstituut Onderzoek der Zee I, No. 1, 1906.

[3]) International Investigations — Marine Biological Association, Report III. pp. 177—206, 1911.

[4]) Svenska Hydrografisk Biologiska Kommissionens Skrifter, VI. (1915). See also O. Pettersson "The Swedish Saving Trawl", ibid. 1925.

[5]) J. O. Borley and E. S. Russell, Report on Herring Trawling. Fishery Investigations, Series II, vol. IV, No. 4, 1922.

the paper referred to, used a $2^{3}/_{4}$ inch mesh as being the normal commercial mesh; nowadays, the effective mesh averages about 2 inches. The view is widely held among practical fishermen that this reduction has gone too far, and that the use of a larger mesh would not only obviate much of the useless destruction now taking place, but by allowing a better flow of water through the net would actually increase its efficiency.

In order to put this question to the test, the Fisheries Department has commenced a series of experimental investigations of which some of the early results are presented in outline in this paper.

The method principally employed in the past in the study of this problem entails the use of fine meshed nets covering the upper side of the cod-end (and sometimes other parts of the trawl) and retaining the small fish which escape through the trawl meshes. This method is undoubtedly of great service but it seems to us to be open to two objections — (1) that the covering net, being of small mesh (e. g. shrimp netting) offers considerable resistance to the flow of water through the net and probably makes it fish less effectively than an uncovered net of the same size, and (2) that the covering net, being under certain conditions, (e. g. in hauling) closely applied to the trawl net proper, may mechanically hinder the escape of some of the small fish.

A second method which may be used is to make alternate hauls over the same ground with two trawls of different cod-end mesh. The objection to this method is that, the fish population being a shifting one, especially if round fish are being sought, there is no guarantee that successive hauls are sampling the same population. All the same, if the hauls are sufficiently numerous, variations due to the shift of the fish should in the long run cancel out and adequate data as to the effect of difference of mesh should be obtainable.

We have, however, worked out a third method which, it is claimed, completely gets over the objections which may be urged against the first two mentioned. This consists in the use of a trawl of standard dimensions and mesh so far as wings, square, belly and batings are concerned, but provided with a bifid cod-end, either leg of which may be constructed of whatever mesh it is desired to test — for instance, one leg may be of 2 inch, the other of 3 inch mesh. There are no covering nets to impede the flow of water, and the question of variation in the population

fished of course does not arise. The appearance of this special cod-end is so like a pair of trousers that it early in our work came to be known as the Trouser Trawl.

It is not claimed for the Trouser Trawl that the results it gives are immediately applicable to full sized ordinary cod-ends, since for one thing the relation between surface and volume (or potential content) is clearly different, and it is realised that the results obtained must be tested out by the second method, using ordinary commercial trawls with full sized cod-ends of specified mesh. The results so far reached are however sufficiently definite to give clear indications as to how further experiments should be devised, and this is the main use of the Trouser Trawl. It gives rapid and unequivocal results which can later be tested out with normally constructed trawls. The aim of the present paper is to describe the new method and give examples of the results obtained; no attempt is made at this stage to deal with the question in a comprehensive manner.

Experiment I.

The Trouser Trawl was first used on a cruise of the „George Bligh" in February, 1925. To a normal „Gourock" trawl, with an 80-foot head line, and batings of mesh grading down from $3^1/_2$ inches to $2^1/_4$ inches (actual)[1]) was fitted a bifid cod-end, of which the upper or undivided part consisted of $3^1/_2$ inch mesh (nominal)[1]) braided down from 100 meshes across to 60 meshes. The length of this part was approximately $8^1/_2$ feet. The legs attached to this undivided part were of 30 meshes across, approximately $13^1/_2$ ft. long and $4^1/_2$ ft. round. One leg was made up of a nominal $3^1/_2$ inch mesh (braided on a 7 inch spool), the other of a nominal $4^1/_2$ inch mesh (braided on a 9 inch spool). The whole cod-end was made of single twine ("100s") and was used white; the rest of the trawl was tarred. There were no flappers or pockets. The actual sizes of the meshes of these two legs after the first haul were 3 inches and 4 inches respectively, as measured by a ruler inside knots, the mesh being pulled out to its full extent. These dimensions represent accordingly the half-circumference of

[1]) "Nominal" mesh means the size of the mesh on the spool (i. e. measured dry; "actual" or "effective" mesh the size after the net has been shrunk by use.

the meshes. The meshes were measured after each of the 9 hauls made; a slight stretching of the smaller mesh, due to the knots tightening up, was observed after the fourth haul, which was a good one ($9^1/_2$ baskets).

The effective working sizes of the meshes during this experiment may be put at $3—3^1/_4$ inches (ca. 8 cm.) and 4 inches (ca. 10 cm.).

The hauls were of three hours duration and were carried out during daylight on the 17th, 19th, 20th and 21st February in moderate to fine weather. On the 20th two hauls were made with a covered Otter Trawl to ascertain the total range of the fish population on the ground. This trawl had a cod-end of double twine (tarred) of mesh just under 2 inches (5 cm.) covered with shrimp netting. The hauls were made in a triangle some miles to seaward of the Haaks Light Vessel on a ground known to carry numbers of plaice of a modal length of about 20 cm. Except in the first three hauls, when the trawl was not fishing well, good catches were made of plaice and dabs, together with a fair number of large flounders, mostly spawning. Round fish, e. g. whiting, were hardly taken at all by the Trouser Trawl, but were captured to the extent of a basket or so in the covered trawl. Sprats, small herring and weevers were also taken by the covered trawl; they were completely absent from the Trouser Trawl catches. The ground was clean and little "weed" or trawl refuse was taken. As the experiment was designed to test the effect of a 3 inch and 4 inch mesh upon flat fish, only plaice and dabs will be considered in this preliminary note. The total range of sizes present on the ground is shown in Table I, which gives the catches by the covered trawl.

Table I. Number at each Cm. length of Plaice and Dabs taken in Otter Trawl (2″ cod-end) and its Cover, (2 hauls combined).

	Plaice		Dabs	
Cm	Cover	Cod-end	Cover	Cod-end
5	—	—	1	—
6	—	—	1	—
7	—	—	3	—
8	—	—	7	—
9	—	—	55	4
10	1	—	70	33
11	3	4	74	37
12	—	11	128	202
13	—	14	62	577

Cm.	Plaice		Dabs	
	Cover	Cod-end	Cover	Cod-end
14	1	41	21	646
15	—	54	3	515
16	1	120	2	520
17	1	256	2	389
18	1	386	—	247
19	—	317	—	110
20	1	426	—	88
21	—	399	—	85
22	—	350	—	62
23	—	282	—	30
24	—	188	—	6
25	—	140	—	20
26	—	63	—	10
27	—	47	—	5
28	—	17	—	—
29	—	1	—	—
30	—	5	—	—
31	—	—	—	—
32	—	4	—	—
33	—	—	—	4
Total...	9	3125	429	3590

It will be seen that the 2 inch cod-end let practically no plaice escape and that the sizes taken ranged from about 10 cm. to 30 cm., with the mode at 20 cm. A fair number of dabs with a modal length of 12 cm. escaped through the cod-end meshes and were taken in the cover, but large quantities were retained by the 2 inch mesh from 12 cm. upwards.

Coming now to the catches of plaice and dabs by the Trouser Trawl, it was found that the individual hauls resembled one another fairly closely; they have accordingly been combined and the results treated as a whole.

Table II. Number at each Cm. length of Plaice and Dabs retained by the $3^1/_4''$ and 4″ legs of the Trouser Trawl (9 hauls continued). Haaks Ground. February 1925).

Cm	Plaice		Dabs		Catch by 4″ leg as percentage of $3^1/_4''$ catch	
	$3^1/_4''$	4″	$3^1/_4''$	4″	Plaice	Dabs
9	—	—	2	—	—	—
10	—	—	11	—	—	—
11	—	—	27	2	—	7
12	1	—	77	2	—	3
13	10	—	123	5	—	4
14	32	3	164	7	9	4
15	62	6	138	10	10	7
16	149	6	161	13	4	8
17	284	18	238	19	6	8
18	804	25	216	18	3	8
19	1105	44	197	15	4	8
20	1286	47	191	21	4	11
21	1398	83	223	26	6	12
22	1211	127	195	24	10	12
23	785	231	122	34	29	28
24	564	299	74	24	53	32
25	312	258	56	23	83	41
26	189	157	30	26	83	87
27	111	96	24	24	87	100
28	56	38	13	10	68	77
29	24	19	12	3	79	25
30	21	10	2	2		
31	7	7	1	1		
32	3	2	1	2		
33	3	—	2	—		
34	2	3	—	1	68	117
35	—	1	—	1		
36	1	1	—	—		
38	—	1	—	—		
40	1	—	—	—		
53	—	1	—	—		
Total...	8,421	1,483	2,300	313	18	14

The data are shown as frequency curves in Fig. 1 and as cumulative percentages in Fig. 2.

It will be seen that the 4 inch mesh allowed the great majority of the plaice under 24 cm. to escape, but took nearly as many as the $3^1/_4$ inch mesh from 25 cm. upwards. Generally, the larger

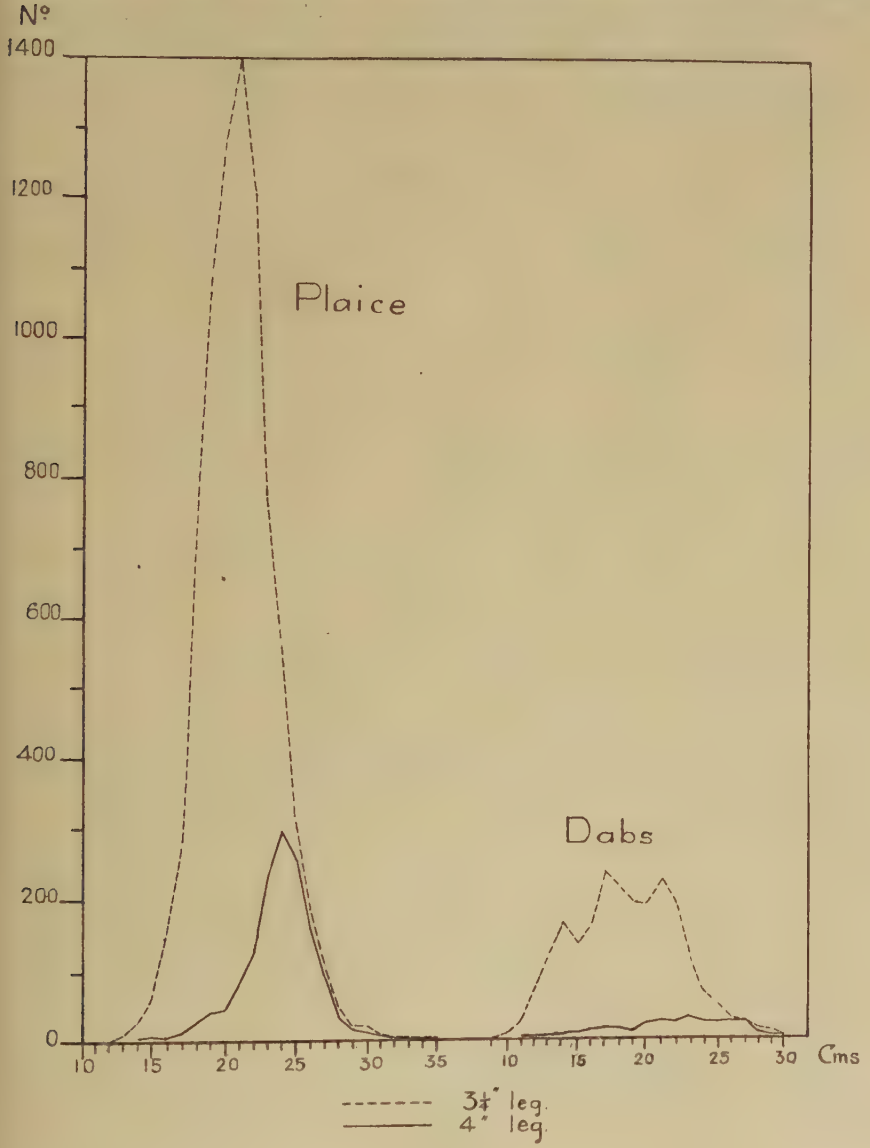

Fig. 1.

mesh retained less than 10 % of the plaice of 22 cm and under entering the net. The 4 inch mesh acts accordingly as a very effective "savings trawl" for plaice under about 25 cm.

A similar selective action is shown also on dabs, which are taken in negligible numbers by the 4 inch mesh, as compared with the 3¼ inch mesh, up to a length of about 26 cm. It is also clear that the 3¼ inch mesh allows to escape large numbers of small dabs which would be taken by a 2 inch mesh (Cf. Table I). It was observed on every occasion when the cod-end was hoisted

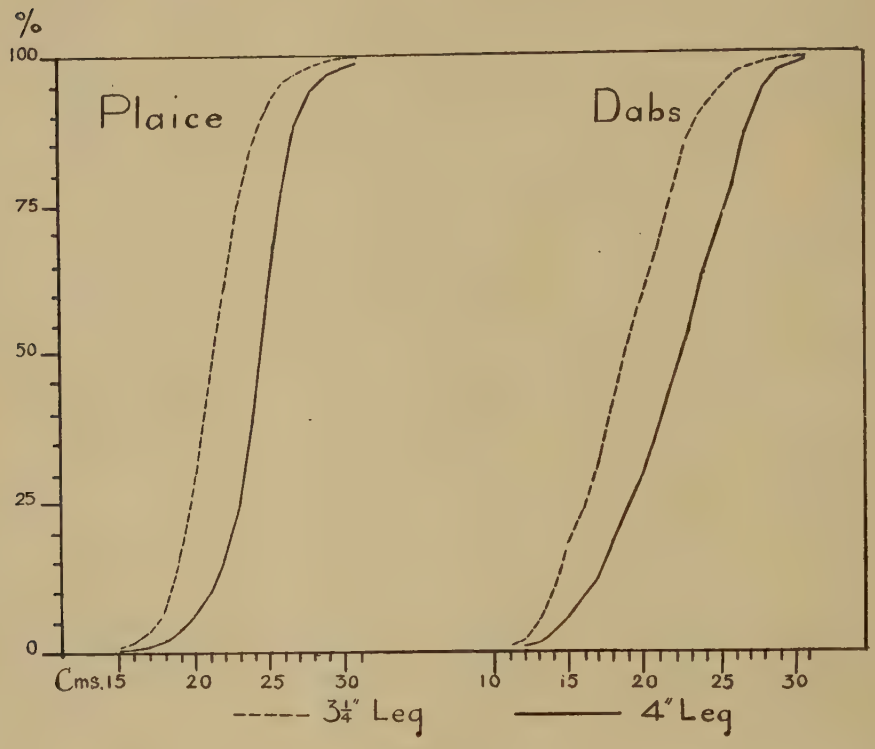

Fig. 2.

on board that many plaice and dabs, particularly in the 3¼ inch leg, were stuck half way through the meshes, and while the cod-end was alongside several were always seen to swim away unharmed.

The cumulative percentage curves (Fig. 2) give the results in another form. The medians and quartiles are given below:-

	Plaice		Dabs	
	3¼"	4"	3¼"	4"
1st Quartile	19.7	23.0	16.2	19.2
Median	21.3	24.5	19.0	22.7
3rd Quartile	23.0	25.9	21.8	25.6

They differ generally by 3—4 cm.

The results for plaice of this experiment on the effect of a 4 inch mesh are of particular interest in view of the fact that 25 cm. is generally agreed to be the size below which it is desirable to protect the plaice from capture.

An estimate in terms of number and weight[1]) above and below 25 cm. of the effect of the 3¼ inch and 4 inch mesh on the catch both of plaice and dabs is given in the following Table:-

	Plaice				Dabs			
	3¼"		4"		3¼"		4"	
	No.	Wt. kg.	No.	Wt. kg.	No.	Wt. kg.	No.	Wt. kg.
Less than 25 cm.	570	45.0	66	6.7	160	10.7	16	1.4
25 cm. and over	54	9.1	44	7.4	10	2.2	7	1.5

The figures are expressed as catch per hour's fishing with a full sized cod-end (catch of leg multiplied by 2).

It appears from this Table that in a single hour's fishing on the Haaks ground the use of a 4 inch mesh instead of a 3¼ inch would result in a saving to the stock of about 500 plaice of less than 25 cm., weighing about 38 kg., and of over 140 dabs weighing about 9 kg. The catch of plaice and dabs 25 cm. and over was somewhat less by the 4 inch mesh than by the 3¼ inch, but it is not known whether this difference is significant or not. The estimate as a whole is of course based upon the assumption that full sized cod-ends of equivalent mesh would show the same degree of selection, and this assumption has still to be tested out.

The average *landings* by English trawlers working in the neighbourhood of this ground in February 1925 were 15 kg. of plaice and 1 kg. of dabs per hour's fishing. It is well known of course that a proportion of the plaice less than 25 cm. are readily marketable; accordingly in order to compare the commercial yield with that of the Trouser Trawl it is necessary to add to the T. T. catch of plaice 25 cm. and over a decreasing proportion of fish under that length. From an examination of the market measurements these proportions can be determined approximately, and it is estimated on this basis that the comparative yields of plaice *as at present marketed* were for the 3¼ inch mesh 38 kg. and for the 4 inch 13 kg. Too much stress need not be laid on this com-

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[1]) Weights were calculated from data given in W. S. Masterman, „Plaice Fisheries of the North Sea" Vol. II, 1909, and T. W. Fulton, "The Rate of Growth of Fishes", Fishery Board for Scotland, Report for 1903, Part III, 1904.

parison which is necessarily not an accurate one, but it does at least show that the Trouser Trawl was making catches of a similar order to those of commercial vessels.

For dabs a similar comparison is more difficult to arrive at, since information is lacking as to what proportion of the catch is brought to market. But the catch of dabs over 25 cm. by both legs of the Trouser Trawl is in excess of the commercial landings per hour's fishing, and it is evident from these figures also that the Trouser Trawl was yielding catches at least comparable with the commercial catches.

Experiment II.

In March 1925 a further trial was made of the Trouser Trawl with $3^1/_4$ inch and 4 inch meshes, working on the Flamborough Off Ground and North Edge of the Dogger. The catches of flat fish were rather poor, and few round fish were taken in either leg, both meshes being too large to catch any considerable proportion of the latter. The data do not merit extended consideration at this stage.

Experiment III.

In order to test the effect of a 2 inch and 3 inch mesh on round fish, a cruise was carried out in July 1925 on the Flamborough Off, Inner Herring Trawling Ground and N. Edge of the Dogger, using a trouser cod-end. The trawl, apart from the cod-end, was the same as that used in Experiment I. The cod-end mesh of each leg was measured after each haul by means of a conical gauge reading in cm. The readings were very consistent at 10—11 cm. for the smaller mesh and 15—16 cm. for the larger. This corresponds practically with 2 inches and 3 inches by the ordinary method of measuring (half circumference).

The cod-end was of single twine and used white.

In all 19 hauls were made with the Trouser Trawl and 2 with a covered Otter Trawl. The weather was good throughout the cruise. The best catches were taken on the Flamborough Off Ground, and it is here proposed to limit consideration to the 10 hauls made on this ground, in which cod, haddock, and whiting

Table III. Number at each Cm. length of Whiting, Haddock and Cod retained by the 2 inch and 3 inch legs of the Trouser Trawl (10 hauls combined) Flamborough Off Ground, July, 1925.

	Whiting			Haddock			Cod		
Cm.	2″	3″	Catch by 3″ as % of 2″ catch	2″	3″	Catch by 3″ as % of 2″ catch	2″	3″	Catch by 3″ as % of 2″ catch
12	1	—	—	—	—	—		—	—
13	—	—	—	—	—		—	—	
14	—	—	—	—	—	—	—	—	—
15	4	—	—	—	—	—	—	—	—
16	15	—	—	—	—	—	—	—	
17	70	2	3	3	—	—	—	—	
18	180	4	2	2	—	—			—
19	254	1	0	9	1	11	8	—	—
20	179	2	1	60	2	3	6	—	—
21	149	2	1	129	10	8	20	1	5
22	207	5	2	182	23	13	19	3	16
23	260	13	5	203	63	31	23	2	9
24	277	15	5	195	82	42	18	1	6
25	161	13	8	131	73	56	32	3	9
26	105	13	12	98	98	100	21	5	24
27	85	5	6	95	98	103	17	7	41
28	36	7	19	103	166	161	19	11	58
29	36	13	36	129	199	154	15	13	87
30	22	6	27	130	197	151	18	12	67
31	16	12	75	86	173	201	27	16	59
32	12	13	108	72	153	212	24	31	129
33	9	3		33	72	218	22	32	145
34	10	4		25	63	252	24	31	129
35	2	6		27	36	133	34	37	109
36	—	3	89	9	16		18	30	167
37	2	3		7	7		23	27	117
38	2	2		5	4	136	21	20	95
39	2	1		3	6		14	22	157
40	—	2		1	1		19	31	163
41	—	—	—	—	—	—	9	17	189
42	—	—	—	—	—	—	10	30	300
43	—	—	—	—	—	—	10	21	210
44	—	—	—	—	—	—	4	16	400
45	—	—	—	—	—	—	8	12	150
46 & over	—	—	—	—	—	—	34	76	224
Total	2096	150	7	1737	1543	89	517	507	98

were captured in fair quantities. The data relating to these three fish are given in Table III, and are shown as frequency curves in Fig. 3 and as cumulative percentages curves in Fig. 4.

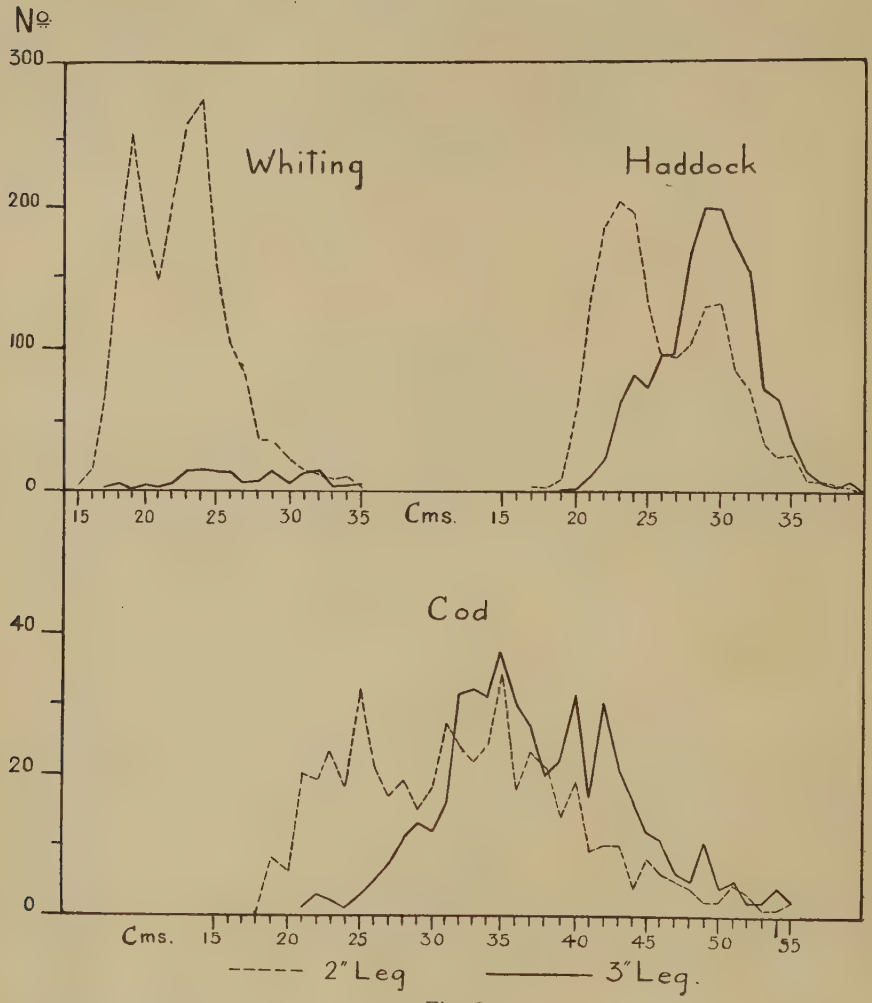

Fig. 3.

It will be seen that on all three fish a very definite selective action was shown by the 3 inch as compared with the 2 inch mesh, the larger mesh retaining far fewer whiting up to a length of about 32 cm., fewer haddock up to about 26 cm. and fewer cod up to about 32 cm.

In the *whiting* catch by the 2 inch mesh the great bulk of the fish lay below about 28 cm., the curve showing modes at 19

cm. and 24 cm. Both these size groups were almost entirely missed by the 3 inch mesh, less than 10 % of those under 28 cm. being retained. With regard to the selective catches over 28 cm., the numbers are small and it is difficult to draw definite conclusions as to whether one mesh was consistently fishing better than the other.

Taking the groups 31—35 cm. and 36—40 cm., the numbers show an excess in the small mesh of 11 out of 41 for the first

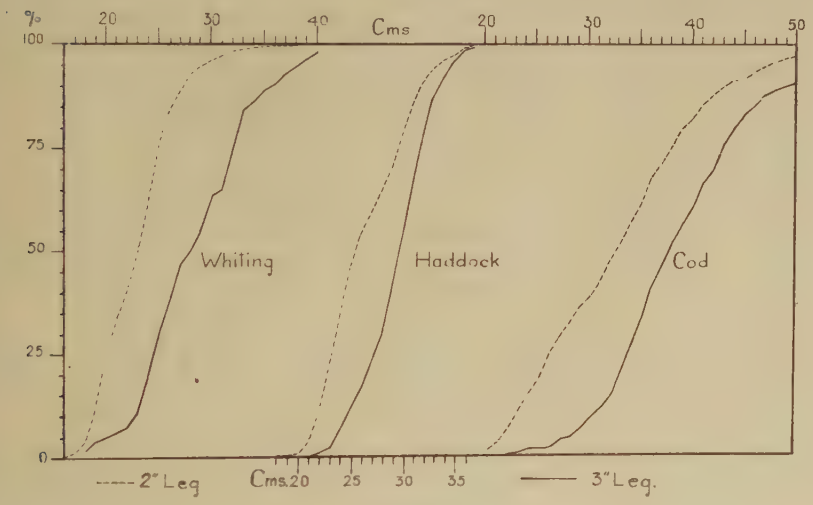

Fig. 4.

group, and an excess in the large mesh of 5 out of 11 in the second group.

The results for *haddock* are particularly interesting, for they show not only that the 3 inch mesh spared a considerable proportion of the size-group centering round 23 cm., but that it yielded considerably larger catches of the fish over 27 cm., than did the smaller mesh. The incidence of capture was thus transferred in part from the smaller and less valuable size-group round 23 cm. to the older and bigger fish centering round 29—30 cm. Up to 21 cm. the 3 inch mesh took less than 10 % of the available fish; equality of capture was reached at 26 cm; thereafter the 3 inch mesh caught increasingly more than the smaller mesh up to 34 cm. when $2^1/_2$ times more were taken; above this size the ratio fell to about $1^1/_8 : 1$.

A similar result was obtained for *cod*, but it is not quite so

clearly shown in the diagram, owing to the irregularities in the curves of the catch both by the 2 inch and the 3 inch mesh.

Up to 26 cm. the 3 inch mesh took less than 10 %; the proportion then rose to nearly 90 % at 29 cm., fell to 60 % at 31 cm., jumped to 130 % at 32 cm., then rose irregularly, but on the whole progressively, to over 200 %. The 3 inch mesh accordingly let through the bulk of the size-group centering at 25 cm., and caught more of the fish over 32 cm. than did the 2 inch mesh. The numbers are rather low and irregular, but by combining in 5 cm. groups a general idea can be obtained of the increase in the catch of the 3 inch mesh as the size of the fish increases.

	16-20 cm.	21-25 cm.	26-30 cm.	31-36 cm.	37-40 cm.	41—45 cm.
Catch by 3″ mesh as % of 2″ catch	0	9	53	112	137	234

The values of the median and quartile are given in the following Table:

	Whiting		Haddock		Cod	
	2″	3″	2″	3″	2″	3″
1st Quartile	19.0	24.6	23.2	27.3	26.2	33.7
Median	22.9	28.0	25.7	29.8	32.6	37.7
3rd Quartile	24.9	32.0	29.7	31.8	38.0	42.9

The differences are for whiting 5—7 cm., for haddock 2—4 cm. and for cod 5—8 cm.

An estimate may be drawn up in the same way as was done for plaice and dabs (see p. 47 above) of the catch per hour's fishing by a trawl with full sized cod-end, giving weights[1]) and numbers above and below 25 cm. for a 2 inch and a 3 inch cod-end respectively. The figures work out as follows:

	Whiting				Haddock				Cod			
	2″		3″		2″		3″		2″		3″	
	No.	Wt.kg.	No.	Wt.kg.	No.	Wt.kg.	No.	Wt.kg.	No.	Wt.kg.	No.	Wt.kg.
Less than 25 cm.	106	7.7	3	0.3	52	4.8	12	1.2	6	0.6	0.5	0.1
25 cm. and over	33	5.7	7	1.7	64	13.2	91	20.3	28	12.5	33	25.1

It would appear from this Table that the saving of the stock effected by the use of a 3 inch instead of a 2 inch mesh would amount,

[1]) Calculated from data given in Fulton's paper above referred to (whiting) and from E. S. Russell, Fishery Investigations Ser. II, Vol. 1 Pt. II 1914 (haddock) and ibid. Vol. V. No. 1, 1922 (cod).

per hour's fishing, to 103 whiting weighing over 7 kg., 40 haddock weighing 3½ kg., and 6 codling weighing under 1 kg. — all being fish under 25 cm. in length. Of the catch of fish of 25 cm. and over there is a loss of 26 whiting weighing 4 kg., but a gain of 27 haddock weighing 7 kg. and of 5 cod weighing nearly 13 kg. Both for haddock and cod it seems — if these data be accepted — that actually a greater weight offish over 25 cm. would be captured by the 3 inch mesh than by the 2 inch. This tentative conclusion requires of course to be substantiated by further experiment, especially with full sized cod-ends, before it can be put forward as established. The average yield of marketed fish from this area by ordinary commercial vessels in July 1925 was 2,2 kg. of whiting per hour's fishing, 22,3 kg. of haddock and 10,6 kg. of cod. These figures compare reasonably well with the catches made by the 2 inch leg, when allowance — great in the case of whiting and small for the other two — is made for the fish rejected by the commercial vessels as unmarketable.

Other Experiments.

In addition to those briefly described above, further investigations have been carried out from the Ministry's Research Vessel both with full sized cod-ends of different mesh and with a Trouser Trawl having in one leg meshes of special shape designed to facilitate the escape of both round and flat fish at approximately the same length. These experiments are however still incomplete, and will be reported upon at a later stage when fuller data are available as a result of further work.

In conclusion, we desire to express our indebtedness for valuable advice and assistance to our colleagues Capt. W. H. Stewart R. N. R., Master of the „George Bligh", and Mr. F. M. Davis, also to Mr. D. Grimwood, the Fishing Mate of the Research Vessel, to whose interest and practical skill much of the success of these experiments is due.

Summary.

1. By means of the „Trouser Trawl", described in this paper, experiments have been carried out which show the selective effect on flat fish of a 4 inch as compared with a 3½ inch cod-

end mesh, and on round fish of a 3 inch mesh as contrasted with a 2 inch.

2. The 4 inch mesh allows to escape a large proportion of the plaice and dabs under 25—26 cm. which are taken by the $3^1/_4$ inch mesh.
3. The 3 inch mesh permits of the escape of a large proportion of the whiting and codling under 32 cm. and of the haddock under 26 cm. which are taken by the 2 inch mesh.
4. While of dabs and whiting the catches above the selection points were approximately the same, and of plaice rather less for the larger mesh as compared with the smaller, the leg with the 3 inch mesh caught considerably greater quantities of haddock and cod above 25 cm. in length than were taken by the leg with the 2 inch mesh.

Reviews.

J. N. Carruthers. The water Movements in the Southern North Sea. Part I. The Surface Drift. Fishery Investigations, Ser. II, Vol. VIII, No. 2, 1925.

Le besoin de données précises sur le transport du plancton et surtout des oeufs et des larves planctoniques a suscité d'actives recherches sur le cheminement des eaux dans les régions côtières et les mers fermées où s'exercent les pêcheries, et l'océanographie dynamique en a reçu une impulsion inattendue.

Des méthodes variées ont été mises en oeuvre; rappelons les principales:

A. l'observation continue des courants de marée avec calcul du courant résiduel et notation de l'action des vents (Comt. Petit, Cap. Phaff, Lt. van der Stock).

B. le prélèvement d'échantillons en séries périodiques pour déterminer le déplacement d'une salinité donnée. (Pettersson, Ekman, Jacobsen).

C. l'étude suivie des migrations de certaines formes planctoniques (Clève).

D. le jet de flotteurs et le pointage du lieu et de la date des récupérations accompagné de l'observation du vent en certaines stations météorologiques voisines et parfois combiné avec des observations de courant.

Cette dernière méthode, malgré son apparence empirique, et sans déprécier la valeur des autres, paraît la mieux appropriée aux buts biologiques immédiats. En effet, elle tend à déterminer directement et sans calcul les aires vers lesquelles les nappes d'eau superficielles se sont effectivement dirigées en glissant plus ou moins sur les masses profondes sous l'action des vents qui, suivant leur incidence, accélèrent, retardent ou défléchissent l'action vectrice des courants alternatifs de marée.

Rappelons que pour la Mer du Nord les premières en date furent celles du Dr. Wemyss Fulton. Conduites avec une méthode remarquable, de 1894 à 1897, elles fournirent des résultats dont l'analyse permit à l'auteur de déterminer les grandes lignes de la circulation superficielle qui, dans les conditions de prédominance normale des vents, se présente comme un tourbillon cyclonique couvrant toute l'étendue de la Mer du Nord.

En 1895, trouvant que les importantes données de Fulton laissaient encore indécise la question des rapports de la Mer du Nord avec la Manche, nous entreprîmes dans la partie méridionale une série d'expériences mensuelles. Leurs premiers résultats, jusqu'en 1901, ont été publiés[1]) mais elles ont été poursuivies encore pendant 3 années ultérieures.

[1]) G. Gilson. Exploration de la Mer. III. Recherches sur la Dérive dans la Mer du Nord. Mémoire du Musée royal d'Historie naturelle de Belgique No. 35, 1924.

Des expériences analogues furent institutées par l'Institut météorologique danois, par l'Institut hollandais pour l'exploration de la Mer, par le Board of Agriculture and Fisheries d'Angleterre, par la Marine Biological Association de Plymouth, par M. Heldt, directeur du laboratoire maritime de Boulogne s/Mer et par d'autres organismes.

Les plus récentes sont celles qui ont été poursuivies par le Ministère de l'Agriculture et des Pêcheries d'Angleterre; elles dépassent en importance tout ce qui avait été entrepris jusqu'ici.

Le nombre des flotteurs libérés entre le 6 septembre 1920 et le 20 février 1922 s'élève à 9500, dont 6435 furent récupérés. Ces chiffres montrent que nos collègues du Fisheries Department et particulièrement le personnel du laboratoire de Lowestoft ont apporté dans l'organisation et l'exécution de l'entreprise cette ampleur et cet esprit de méthode et de suite qui caractérisent tous leurs travaux. C'est à M. Carruthers, que fut confié le soin d'en exposer les principaux résultats. C'était là une de ces tâches extrêmement laborieuses et difficiles devant lesquelles se trouve fréquemment aujourd'hui l'homme de science pratiquant les méthodes d'investigation modernes qui comportent le travail souvent écrasant de la manipulation des grands nombres. D'une part de longues séries de données lui sont nécessaires, et de l'autre, ces séries une fois obtenues il se trouve devant des accumulations de matériaux ou de chiffres tellement énormes que leur maniement devient très pénible et qu'il est fort difficile de les traiter de manière à en dégager naturellement des conclusions qui s'imposent.

M. Carruthers déclare qu'il s'est proposé comme but principal de son travail la préparation d'un instrument d'utilité pratique pour l'étude des problèmes qui se posent dans les recherches concernant les pêcheries. Un simple exposé détaillé de tous les faits acquis n'aurait point atteint ce but car le lecteur se serait vu obligé de rechercher lui même dans d'interminables listes et tableaux les indications utiles à son étude spéciale. Renonçant donc à publier l'histoire détaillée de chacun des flotteurs, il s'attache à présenter au lecteur des résultats synthétisés par le procédé suivant: il divise la Mer du Nord, à partir de chacun des 7 bateaux-phare utilisés comme point de départ, en 16 secteurs correspondant aux 16 principales divisions du compas. Ces secteurs, poursuivis jusqu'à la rencontre d'une côte, limitent sur celle-ci une plage d'échouage des flotteurs. Il est dressé pour chaque expérience des tableaux indiquant:

A. la date du jet des flotteurs;
B. le secteur d'échouage (ou de trouvaille en mer);
C. le nombre de flotteurs récupérés;
D. la distance moyenne parcourue;
E. la vitesse atteinte par les flotteurs les plus rapides;
F. le nombre moyen de jours écoulés entre le jet et la récupération;
G. le vent résiduel de la semaine suivant le jet;
H. le vent résiduel de chaque mois écoulé après le jet.

Ces deux dernières données sont extrêmement importantes; l'influence des vents sur la dérive est trop bien établie pour qu'on puisse s'exempter de recueillir à leur sujet les indications les plus précises.

Cette tabulation synthétique jointe aux calculs nécessaires pour

obtenir le "vent résiduel" de la période comprenant plus de 11000 observations, représente un travail vraiment énorme. Mais le résultat de ce labeur atteint, dans une large mesure, le but que l'auteur s'est proposé. L'investigateur occupé d'une question de pêcherie comportant la connaissance du cheminement du plancton ou du frai planctonique peut espérer de découvrir dans les tables, les cartes et les commentaires qui y sont joints, une période de conditions météorologiques comparable à celle qui l'intéresse et lui permettant de supputer la direction probable de la dérive et la distance parcourue par des flotteurs et même par les eaux de surface. Nous ne pouvons songer à donner ici un exposé même sommaire de tous les résultats tabulés par l'auteur ni des remarques critiques dont il en accompagne l'étude. Pareil résumé n'exempterait nullement le chercheur de recourir aux tables et aux pages concises du mémoire lui-même. Contentons-nous d'énumérer quelques unes des données de fait et des principales conclusions contenues dans le mémoire très substantiel de M. Carruthers.

Les flotteurs ont été mis à la mer du bord de 7 bateaux-phare dans la partie Sud de la Mer du Nord: le South Dogger Bank (temporaire, supprimé), l'Outer Dowsing, le Swarte Bank, le Smith's Knoll, le Galloper, le North Hinder et le Sandettie. — Voir dans le texte les indications techniques intéressantes: préparation, lestage, fermeture des bouteilles à soda, formule incluse, disposition en vue de la récupération, etc. —

Une attention toute spéciale a été accordée au problème difficile de l'action indéniable des vents sur la dérive des corps flottants. On a utilisé les observations faites toutes les 4 heures à bord de l'Outer Dowsing, du Swarte Bank, du Smith's Knoll, du Galloper et du Sandettie.

Une sérieuse amélioration sur le procédé très simple de la construction graphique d'une observation journalière unique, pratiqué par Fulton et ses successeurs, a pu être réalisée grâce à l'obtention des six observations, faites à bord des bateux-phares, dont on a déterminé l'action vectrice moyenne en direction et en force. Il n'est pas douteux que les données ainsi obtenues fournissent, dans les conditions de discontinuité de l'observation usuelle du vent, le meilleur procédé d'investigation de la relation existant entre la direction et la vitesse des vents, d'une part, et la dérive des corps flottants, de l'autre.

Mais les calculs nécessaires, portant sur les 11000 observations impliquent un labeur vraiment énorme et qui n'a pu être accompli que par la coopération d'un personnel capable et bien organisé.

Armé de ces données du vent résiduel l'auteur expose les résultats de chacun des jets de 25 flotteurs exécutés hebdomadairement à bord des 7 bateaux-phare.

Les tables contiennent une riche moisson de faits bien catalogués. Les investigateurs de l'avenir qui voudront y puiser se trouveront puissamment assistés par les considérations interprétatives que l'auteur expose au sujet de ces faits, en vue de la détermination de l'action du vent sur la dérive des corps flottants soumis en même temps à des actions vectrices non éoliennes.

M. Carruthers ajoute à l'exposé des données de vent et de récupération recueillies au cours de toute la période d'expérience, une tabulation par

saison et par mois, pour chacune des 7 stations. Puis, armé de ces données, il tente d'établir un tableau général du régime de la circulation des eaux de surface au cours des différentes saisons de l'année. Il dresse ce tableau pour 5 périodes correspondant à une prévalence prolongée des vents du Sud (Automne), du Nord-Est (Mai), du Sud Sud-Ouest (Hiver) du Nord et du Nord-Ouest (Printemps), et de l'Ouest — partie Nord (Été).

Cinq cartes montrent le tableau général de la circulation superficielle moyenne et probable au cours de ces périodes. Elles constituent des éléments utiles pour la supputation des probablités de la dérive saisonnière et font désirer que ce même travail soit répété dans l'avenir et porte sur une longue série d'années.

L'ensemble du travail constitue, répétons-le, la plus puissante contribution qui ait été apportée jusqu'ici à l'étude de la dérive dans la Mer du Nord. Ses résultats fournissent de sérieux éléments aux recherches qui doivent encore se poursuivre sur le transport des matériaux planctoniques dans nos eaux et à toutes les investigations portant sur les déplacements des poissons au cours de leur phase planctonique et sur ceux du plancton lui-même qui joue un si grand rôle dans l'économie biologique de la mer. D'une manière générale on peut dire que cette expérience faite sur une échelle supérieure à tout ce qui avait été tenté jusqu'ici confirme dans ses grands traits le tourbillon circulatoire de Fulton, qui comprend un courant descendant sur la côte occidentale, britannique, de la Mer du Nord, et un courant ascendant le long de la côte orientale Hollando-Danoise, unis par un courant transverse dans la partie Sud, vers les parallèles 51°—55°. Mais les vents suffisamment persistants soufflant de la partie Sud et Sud-Est peuvent en modifier le cours, même au point de le renverser pendant quelque temps, au moins dans la région Sud et Ouest. Ce qui se passe quand ces mêmes conditions viennent à prévaloir dans la partie centrale et septentrionale, est moins nettement établi, mais il est vraisemblable que le même renversement peut s'y produire car les courants de marée étant d'une moindre vitesse à distance des côtes, l'action des vents doit s'y exercer d'une façon plutôt plus marquée, et le transport des eaux de surface, du plancton et des oeufs et larves, doit y être sujet à des fluctuations plus dépendantes de l'action éolienne c'est-à-dire plus capricieuses, plus sujettes à des variations imprévoyables.

On voit que quelque méritoire que soit le gigantesque travail de nos collègues anglais et la laborieuse et sagace analyse de ses résultats publiée par Carruthers il reste à désirer que des investigations du même ordre soient encore poursuivies. Nous attendons avec grand intérêt la publication des résultats obtenus par la méthode des flotteurs de fond (bottom drifters) qui nous est annoncée, ainsi que celle de nouvelles observations continues sur les courants et sur les variations de la salinité. Si on veut arriver à prédire la dérive avec quelque probabilité, il est nécessaire que l'on ne néglige aucun ordre d'information.

A ce propos nous nous permettons de formuler deux remarques qui nous paraissent mériter l'attention des expérimentateurs:

1. D'abord, il serait à désirer que l'on obtienne des observations continues du vent à bord des bâteaux-phare. En effet, l'action

du vent sur un flotteur n'est pas la même à toutes les phases de la marée. Ainsi, par exemple, un vent déflecteur, c'est-à-dire transverse par rapport à la direction flot-jusant, soufflant pendant l'étale de courant ou pendant la période giratoire, alors que le courant est nul ou très faible, conduira un flotteur beaucoup plus en dehors de la route du courant résiduel que s'il agit pendant que le courant est dans toute sa force. Un même vent produira un effet différent, c'est-à-dire portera un flotteur en une autre région, s'il souffle pendant les heures de plein courant que s'il agit en dehors de tout courant ou par un courant faible. Il serait donc intéressant de posséder un appareil enregistrant la direction et la vitesse du vent en même temps que la direction et la vitesse du courant.

Sans doute, pareil instrument sera toujours difficile à installer à bord des bateaux-phare à cause de la giration du navire sur son ancre au changement de courant. Toutefois il ne paraît pas impossible d'imaginer une combinaison de l'anémomètre et du gyroscope qui éliminerait le facteur giration du navire.

2. Un autre point que nous voudrions mettre en relief est l'intérêt que présente l'emploi de flotteurs accouplés, dont l'un est flottant et l'autre, relié au premier par un lien plus ou moins long, est lesté au point de sombrer mais non de faire couler le premier. Il est clair que celui-ci opposant au vent une très faible surface et arrêté dans sa dérive éolienne par la résistance opposée par l'eau à son associé sombrant, prendra une direction et une vitesse très peu différentes de celles de la couche d'eau superficielle qui les contient tous deux. Or c'est le mouvement de cette couche d'eau qui présente tout l'intérêt au point de vue biologique. C'est cette remarque qui nous a conduit à employer ce genre d'appareil en même temps que des flotteurs simples. Nous comptons publier prochainement l'exposé d'une longue série d'expériences dans lesquelles les flotteurs accouplés ont donné des résultats nettement différents de ceux des flotteurs libres.

Il est à espérer que nos collègues britanniques songeront à ces deux desiderata dans l'emploi de leurs puissants moyens de travail qui promettent encore à la science de belles recherches et de nouveaux progrès.

G. Gilson.

Ostende.

H. W. Harvey. Hydrography of the English Channel. Conseil Permanent International pour l'Exploration de la Mer. Rapport Atlantique 1924. Copenhague 1925.

Hydrographical investigations in the English Channel have proceeded now for more than twenty years and it is therefore a timely object which Mr. Harvey has achieved in bringing together the results of researches bearing on the hydrography of these waters. This work will undoubtedly rank as standard for some time to come, not only to those engaged

on the hydrography of the English Channel but to everyone having an interest in fishery research. Its value for purposes of reference, however, might possibly have been enhanced if some of the sections relating to water movements had been elaborated in somewhat greater detail, as for instance the section dealing with the rate of flow through the Channel. It is known that the rate of flow varies considerably but it is perhaps premature to attempt the establishment of a mean value. Moreover, the results of plankton distribution studies, which have a bearing on water movements[1]), are not considered.

It is now a well established fact that water flows from the Atlantic into the English Channel. This flow appears to be governed to a large extent by the Atlantic Stream (the name "European Stream" is suggested as preferable for general adoption) which flows northwards along the European shelf, but our present knowledge of this stream is slight.

Besides the eastward movement of water through the English Channel, a feature which is important in any consideration of the hydrography of these waters is the counter-clockwise circulation which exists off the Channel's mouth, south of Ireland (vide Fig. 19 p. 65).

As is to be expected these systems of movement undergo perturbation from time to time. Emphasis is laid, and rightly so, on the importance to fishery investigations of studying the fluctuations of these movements, but before discussions of departures from the normal are justified, it must of course be ascertained that a reliable reference datum has been set up. It can now be accepted as certain that an annual fluctuation occurs in the flow of the water entering the English Channel, and evidence is produced which suggests two further periods of 2 and $18^1/_2$ years. Matthews suggestion[2]) that two pulses may be experienced during the course of the year is not, however, touched upon.

On p. 65 line 7 a reference occurs which, on Mr. Harvey's information, should read "(34)". It is doubtful whether the uprising of the current in the shallows of the eastern basin of the Channel may be accepted as a general condition, as the reference is to a special case. There is moreover another explanation of the fact that the salinity in the eastern basin towards Dover Straits is sometimes higher than it is slightly further westward, namely, that water of low salinity from the River Seine moves off-shore and cuts athwart the salter tongue.

Considerable attention is given to a discussion of temperature conditions, and an interesting method is described whereby reasons may be found for irregularities occurring in the seasonal flow of temperature. A list is made of the factors controlling fluctuations in the seasonal variation of temperature at a particular spot, and it is interesting to note the importance of the rôle of the thermocline (where the depth of water is sufficiently great to permit its formation) in regulating the amount of heat which may be gained by the water in summer. In hot calm summers less heat may be gained by the water mass as a whole than in summers with more wind and less solar radiation. These conclusions do not of course

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[1]) Cf. Gough L. H. Publ. de Circ., no. 29. 1905.

[2]) Fisheries, Ireland, Sci. Invest. 1913 IV (1914). p. 22.

refer purely to the English Channel and justification might perhaps have been found for adding to this section a note on the method by which the temperature wave itself may be studied. A reference to the work in question is, however, given in the bibliography [(43)] and a further paper by the same author[1]) is not without bearing on the temperature conditions in the English Channel.

The concluding sections (of general as well as local interest) deal with changes in the physical characteristics of sea water and their biological significance. The section concerning the distinction between inshore and offshore waters is of special interest in view of the advances which have recently been made in this connection. Besides differences in salinity and temperature, the chief difference between these two types of water evidently resides in the greater quantity of organic matter dissolved in the former, and incidental to this other changes take place which differentiate coastal water from that of the open sea. In the Introduction to the treatise variations in phosphates and nitrates are considered in relation to their power of limiting the fertility of the sea (Liebig's law of the minimum). As regards the significance of the physical features of sea water with respect to the fisheries the correlations which have been attempted do not appear very conclusive and further research in this direction is clearly needed.

Evidently there is a misprint on p. 87, line 12; "surface" should surely read "bottom trailing".

J. R. L.

A. C. Gardiner, M. A. and Michael Graham, M. A. The Working Error of Petersen's Young Fish Trawl. Ministry of Agriculture and Fisheries. Fishery Investigations Series II, Vol. VIII, Nr. 3, 1925.

In this paper an account is given of an experiment designed to test the value as a quantitative fishing implement of the mesoplankton net usually known, after the name of its designer, as the Petersen young fish trawl.

A series of ten hauls were made in the southern North Sea under conditions as uniform as possible, the net being towed round a circle of two miles in diameter, each haul commencing at the bottom and by the shortening of the warp at regular intervals ending at the surface. The total catch of each haul was counted or estimated from a measured sample.

The takes of six selected organisms or groups were then compared in each of the hauls, the total number and probable error, both actual and percentage, being calculated for each. The probable errors for the six examples varied from $\pm$ 27 to $\pm$ 54 per cent. These figures are compared with those given by Herdman from Nansen net hauls off Port Erin, which show a very similar variation.

The value of these figures as evidence against the net depends on the assumption that the distribution of Plankton in the sea was uniform. If the variation in the catch can, as the authors believe, be ascribed to

[1])Fisheries, Scotland, Sci. Invest. 1916 I (February 1916).

uneven distribution the accuracy of the net may be much greater than is indicated by the figures. In fact the authors regard the maximum error of the net as not more than ± 27 per cent.

There are no doubt factors which still remain to be tested, some evident, such as the weather and the presence of clogging organisms, and some probably quite unexpected, but in the meanwhile this evidence in favour of such an efficient fishing implement as the young fish trawl is very welcome.

F. S. Russell, D. S. C., B. A. The Vertical Distribution of Marine Macroplankton. An Observation on Diurnal Changes. Journal of the Marine Biological Association. N. S. — Vol. XIII, Nr. 4, October 1925.

The vertical movement of plankton is a subject in which a great deal of interest is professed and on which numerous desultory observations have been made, but cases of its systematic investigation have been regrettably few. This paper gives an account of a very useful addition to the list.

In Juli 1925 five series of horisontal ten minute hauls were made off Plymouth between 3.25 p.m. and 10.11 a.m. the following day with a 2 metre ring net of stramin towed at various depths down to 34 metres in water of 51 metres in depth. The depth of the net was given in each case by an attached depth recorder.

A large number of species were taken, most of them in considerable numbers, much more than could have been obtained in vertical hauls. These large catches, as the author points out, add greatly to the value of the record, as they tend to smooth out differences in horizontal distribution, so that what is lost in accuracy in one direction, owing to the variation in the depth at which the net is towed, the absence of a closing apparatus and the long time occupied by a series of hauls, is compensated for in another.

For each of the species taken a table is given showing the numbers at each of five depths at daylight, dusk, midnight, dawn, and again at daylight. The movements deducible from the tables divide the species into groups, each group including diverse forms. The largest group consists of those which showed no reaction to the change from day to night. Another well marked group is made up of those forms, such as Amphipods, Mysids and Cumaceans, which at night move upwards from a daylight habitat on or close to the bottom. Equal in numbers to these are species which show a definate migration to the surface, the author adds "at night", but as the data indicite that *Calanus finmarchicus*, which is included, had already reached the surface at sunset and had begun to leave it before midnight the implication that the movement is always a reaction to darkness seems to need qualification. A smaller group shows an extension upwards, but short of the surface, of a daylight midwater habitat.

The daylight distributions also fall into distinct groups the most

clearly marked one consisting of species with a maximum between 10 and 20 metres diminishing rapidly towards the surface and more gradually towards the greatest depth investigated. Another shows a gradual increase from at or near the surface to about 30 metres; an additional haul between this depth and the bottom would have been informative but no doubt practical difficulties prevented it. The resumption by almost every species next morning of the exact daylight distribution of the previous day is good evidence of the reliability of the methods employed.

The author justly points out that his paper is only a record of what occurred on one occasion under certain definite conditions. One hopes that it is only the first of a series of such records.

MARIE V. LEBOUR, D. Sc., F. Z. S. The Dinoflagellates of Northern Seas. Plymouth. Published by the Marine Biological Association of the United Kingdom 1925.

In this work Dr. LEBOUR gives in a convenient form a summary of present day knowledge of the Dinoflagellates or Peridinians of northern waters, including littoral and brackish water forms, with figures and description of all species known therefrom. It is based on PAULSEN's account of the group in Nordisches Plankton published in 1908 and, for the naked forms, on KOFOID and SWEZY's monograph, 1921, the reader being referred to those authors for synonymies. The book is however very much more than a summary of previously published work. It is a critical revision of the northern forms, any new views put forward or departures from the opinion of other authors being adequately discussed. Incidentally eighteen new species are described and figured.

Original figures drawn from specimens observed by the author are given of almost every species mentioned in a series of well drawn plates and, in the few cases where these were not available, copies from other authorities have been inserted in the text. The plate figures are all drawn to the same scale, based on the requirements of the smallest species. This is a convenient arrangement for those who do not readily visualise numerical dimensions and also, in the case of townet collections, shows directly what forms would normally escape capture by meshes of various sizes. It results however in some of the larger species such as *Ceratium* occupying more than their fair share of room.

There is a short introduction dealing with morphology and habits, a classification revised by the author, an appendix with technical hints and a list of relevant literature. The book is published at Plymouth by the Marine Biological Association and is turned out with the same attention to detail and in the same clear type as the Association's Journal. It is perhaps unnecessary to add that it will be indispensable to all microplankton workers.

R. E. Savage, A. R. C. Sc., D. I. C. The Food of the Oyster. Ministry of Agriculture and Fisheries, Fishery Investigations, Ser. II, Vol. VIII, Nr. 1. 1925.

A valuable and interesting account is given in this paper of a series of comparative observations, covering a complete year, on the feeding of the oyster, carried out on the coast of Suffolk at two adjacent oyster-beds, one of which had excellent fattening properties which were lacking in the other. Tables are given for each month of the year both of the gut and stomach contents of the oysters from each bed and also of townet collections made above the beds, the volume of each species as well as the actual number being tabulated. Tables are also given for comparison of townet collections and stomach contents of oysters from the oyster tanks at Conway in North Wales, where the oyster breeding experiments of the Ministry of Agriculture and Fisheries have been carried on.

One of the most interesting sections of the paper is that where the value of detritus or disintegrated organic substance as a food material is considered. The author supports the view of Dr. C. G. J. Petersen and his colleagues and some other recent workers that this substance has a very important rôle in the food supply though he recognises that the actual amount of detritus present in the water must vary very much in accordance with local conditions. He put forward the suggestion that growth is due mainly to inanimate food, i. e. detritus, and fattening to diatoms, basing his view on the chemical composition of the food and on the fact that fattening took place on the one bed where the supply of animate food, consisting mainly of diatoms, was four times as large as on the other, the total food consumption on each bed being approximately equal.

Another point to which attention is called in the paper is the possible destruction of oyster larvae by the oysters themselves. In the townet collections from both oyster beds the larvae were present in moderate quantities from August to October and were also found in appreciable quantities in the gut contents of the oysters from both localities. In the water of the Conway oyster tanks mentioned above the larvae were present in large numbers from July to September and in the stomachs of the oysters from the tanks they reached at times the amazing figure of 96 per cent by bulk of the total contents. Fortunately as has been shown some of the larvae can survive the passage through the gut of their parents.

The general conclusions reached by the author cannot be better summed up than by quoting his own words: —

1. The greater part of the food found in the oysters examined was inanimate ("organic detritus"), the animate food never exceeding 10 per cent. of the total.
2. The feeding period extended from July to October or November, with a short season of brisk feeding during August and September. During the remainder of the year there was very little food found.
3. There was a definite difference in the quantity and quality of the animate food in the oysters taken from the beds where they "fatten"

well (Butley Creek) and in those from the beds (Main Channel) where fattening is less satisfactory.

4. There is an apparent relation between the consumption of diatoms and "fattening", the principal species of diatom taken being *Nitzschiella longissima* f. *parva*.
5. Metazoa formed part of the food when the vital activities of the oyster were at their highest. Peridinea were practically absent from the plankton in the waters above the beds, and in consequence very few were found in the food.
6. When actively feeding the oyster appears to ingest anything suitable that it can capture, and no evidence was found to show that selection takes place.
7. It is suggested that growth is due mainly to inanimate food, and "fattening" to diatoms.

In addition to the record of the experiments the paper contains a précis of previously published work on the subject in which thirtyfour papers are summarised.

The careful quantitative and qualitative observations made by the author may well serve as a standard for future work on oyster nutrition and it seems likely that the extension of these methods to other localities and conditions will throw light on many questions which have long been a puzzle to oyster cultivators.

A. C. Johansen. On the Influence of the Currents upon the Frequency of the Mackerel in the Kattegat and adjacent parts of the Skagerak. Meddelelser fra Kommissionen for Havundersøgelser. Serie: Fiskeri, Bind VII, Nr. 8, 1925.

This is an interesting study in the correlation of the movements of the mackerel with hydrographical conditions, and opens up the possibility of predicting a month or two in advance whether the fishery in the Kattegat will be good or bad.

As is well known, there is in the Belts and the Kattegat an outflowing surface current from the Baltic of low salinity, beneath which is found an inflowing current of salter water from the North Sea. In the course of a cruise in the "Dana" in April and May 1923 Dr. Johansen observed that this undercurrent was of a higher salinity than usual, and carried with it a plankton population of a more than usually oceanic type, indicating that water of Atlantic origin was entering, along with the North Sea water. The yield of mackerel in the Kattegat was much higher than usual in 1923, which led Dr. Johansen to investigate whether there was a connection between the two phenomena.

He shows in this paper that there is a positive correlation between the percentage catch-anomalies of mackerel in the Skagerak and Kattegat and the salinity-anomalies in the bottom water (at 26 metres) at Schultz' Grund light vessel in May, the coefficient of correlation rising as high as

0.73 in one period. There is therefore a definite relation between a good catch of mackerel in these waters during the fishing season (June to September) and high salinity at the bottom in the Kattegat (southern part) in May, and to a less extent in April. There does not appear to be a direct causal connection between the two phenomena, as it is improbable that the mackerel immigrate in the bottom current. A high salinity in the bottom layer at Schultz' Grund light vessel in May is normally followed by a increase in the surface salinity and a decrease in the surface temperature in June and July, and the probability is that the mackerel enter these waters in the upper layer in search of water of a suitably high salinity and low temperature in which to spawn. Between the surface temperature in June in the Skagerak and the catch of mackerel there is a pronounced negative correlation, i. e. lower temperatures than normal are followed by good catches, higher temperatures by poorer catches.

Dr. JOHANSEN concludes that "there is a connection between the following phenomena in the Kattegat: — (1) A strong ingoing current in the lower water layer in April—May, indicated by a high salinity in this layer, (2) A low temperature of the surface waters in June, (3) A great amount of mackerel in the Kattegat, as shown by a large yearly catch" (p. 25).

It is also shown that a high salinity in the bottom layer in May is normally preceded by a low salinity in the surface layer in March—April. It is therefore possible as soon as the surface salinity is known in March and April to prophesy whether the mackerel season is likely to be good or bad, and when the salinity of the bottom layer in April and May has been ascertained the prediction can be made with greater confidence.

Dr. JOHANSEN proposes to publish such predictions in the „Dansk Fiskeritidende", and it will be very interesting to see what success attends them. Reliable predictions of this kind would be of great practical value, and would help to bring home to the industry the utility of fishery research.

E. S. R.

C. F. HICKLING. A new Type of Luminescence in Fishes. Journal of the Marine Biological Association of the U. K., N. S., XIII, pp. 914—37, 1925.

In the course of his investigations on the hake fishery carried out on commercial trawlers in the Atlantic Slope area south of Ireland Mr. HICKLING discovered that the Macrurid *Malacocephalus laevis* (Lowe) possesses a luminous organ in the vicinity of the anal papilla. He gives in this paper a careful and well illustrated account of the anatomy and histology of the organ. "It consists essentially of an epithelium for the secretion of luminous substance, which has been thrown into long folds and wholly invaginated to form a gland. This gland is bound in connective tissue and has a compact appearance, and is furnished with supporting tissue internally. The duct is a flat and wide passage, continuous with the gland, which opens to the exterior about the anus in such a way as to surround the lower part of the rectum. The gland lies in the thickness of the body-

wall forward of the rectum and between and behind the pelvic fins" (p. 928).

The gland may have a muscular sheath of its own, but the body-wall muscles are probably sufficient to squeeze out the luminous secretion. The fish can accordingly emit a cloud of light, just as a cuttlefish shoots out a cloud of ink. The cloud of light may serve a protective function, in distracting the attention of a pursuer while the fish itself gets away, or it may possibly act by attracting the crustacea on which the fish feeds.

The light is probably not due to luminous symbiotic bacteriea as in certain other fish, but to the oxidation of luciferin in the presence of the ferment luciferase, as in *Pholas* and fireflies.

The experiments carried out on the nature of the secretion by Mr. Hickling under the bad conditions of work on a trawler are ingenious and creditable, but further study of it would be desirable.

E. S. R.

P. Chevey. Rapport sur les Pêcheries ou Bouchots de la Baie du Mont Saint Michel. Notes et Mémoires. Nr. 44. Office Scientifique et Technique des Pêches Maritimes. Paris 1925.

This report is focussed on one point, viz. the alleged destruction of undersized fish by the pêcheries ou bouchots (fish hurdles), of which there are forty in the region of Cancale. The report shows that the "accusation" is justified; but does not include within its province the larger question as to whether the destruction is justified.

The young of thirty edible fishes are caught in these fish hurdles. Some are caught in thousands (e. g. Sprats and sometimes Plaice), some in hundreds (e. g. Herrings, Sardines, Mackerels, Plaice) per fishery; and they are caught in such a way that extremely few can escape destruction, even when returned to the water by the hand of the fisherman. This is clearly explained in the chapter on the "Fonctionnement des Pêcheries," which is illustrated by two views of the apparatus.

From July 1923 to October 1924 samples were taken of from one to five fisheries per month; but whether the weight or volume of each sample was determined is not stated. This is not, however, an unimportant detail, because the report includes graphs purporting to show the relative numbers of the Young (i. e. under 10 cm: Sprats under 6 cm) of certain species at different periods of the year; but the reader is not told how these relative numbers were arrived at. The bulk of the report consists of thirty tables in which are recorded the average length or range of length of each species in each sample. In the table for Herring there are apparent indications of a double spawning period; but, since the measurements of individual fishes are not tabulated, the evidence on this point is not sufficiently clear. The first two annual groups of the Sprat are well represented, as is also the case in the Whitebait fishery of the Thames Estuary and elsewhere.

Of considerable interest is a diagram showing that the yearling fry of different species appear in the fishery in a certain succession in Spring,

and disappear in Autumn. The disappearance in Autumn is evidently due to two causes: —

1. growth to lengths exceeding the specified size-limit, and
2. emigration from the tidal area into deeper water. W.

Henry Wood, M. A. & George McGee, D. S. M. Aircraft Experiments for the Locating of Herring Shoals in Scottish Waters, Fishery Board for Scotland, Scientific Investigations, 1925, Nr. 1.

L'expérience avait montré en divers pays, que des bancs de poissons: sardines, saurels, thons, pouvaient être aperçus d'un dirigeable ou d'un avion et signalés aux pêcheurs.

La question se posait pour le hareng. Elle était d'importance: on conçoit l'intérêt d'une méthode qui éviterait au pêcheur des recherches incertaines et coûteuses en lui indiquant la position des bancs. Le "Fishery Board for Scotland", par des essais rationnels, a voulu arriver sur ce point à des conclusions décisives. Rien n'a été négligé pour la réussite des expériences dont MM. Henry Wood et George McGee viennent de publier les résultats.

"The Air Ministry" envoya des hydravions, l'Amirauté détacha H.M.S. "Exe" pour coopérer aux opérations avec le bâtiment du "Fishery Board" "Minna". Tandis que ces navires transmettaient par sans-fil les nouvelles du large, les postes de la côte adressaient tous les renseignements utiles à la base d'Invergordon. — De cette base, des appareils partaient chaque jour rejoindre la flottille des drifters. Ils explorèrent ainsi une zône étendue, à fonds variés, pendant la période où la pêche y a son activité la plus grande.

Les observateurs s'étaient proposé de déterminer dans quelle mesure, aux conditions normales, les bancs de harengs, dont la présence est connue, peuvent être repérés; puis, ce résultat acquis, de tenter, en des randonnées rapides, la recherche des bancs pour les signaler aux pêcheurs.

Dans les meilleures conditions de visibilité, on ne peut distinguer à plus de 6 brasses de profondeur. Il ne faut donc espérer voir le hareng que lorsqu'il s'élève dans ces limites: tôt le matin ou tard le soir. Encore un effet de nuages ou un léger clapotis peut-il masquer le phénomène. — Il fut observé pourtant, mais une seule fois au cours de 32 vols. Deux observateurs le signalèrent simultanément. A faible altitude il était possible de distinguer les poissons; de plus haut, le banc, agitant la surface, donnait l'impression d'une violente averse sur l'eau. — La visibilité était ce jour là parfaite: ciel clair, mer calme, pas de vent. Sans ces conditions, exceptionnelles à ces heures et sous ces latitudes, la découverte des bancs est incertaine.

Les patrons harenguiers déduisent la présence du poisson de certains phénomènes apparents. MM. H. Wood et G. McGee ont également noté ces indices et mis en parallèle leurs observations avec les résultats des pêches dans les régions correspondantes: La répartition des gannets ou "solan geese" sembla toujours correspondre avec la distribution des bancs; mais aucune concordance ne s'observa entre l'abondance des captures

et la présence en surface de taches huileuses, de dauphins ou les rassemblements d'oiseaux autres que les gannets.

Un appareil rapide présenterait donc de grands avantages pour localiser ces phénomènes, mais ceux-ci ne permettent pas de guider le pêcheur avec certitude.

Étant données la durée, la continuité et la diversité des expériences de MM. H. Wood et G. McGee, la maîtrise avec laquelle elles furent organisées et conduites, il n'est pas permis de revenir sur leurs conclusions.

Les auteurs les considèrent toutefois comme valables sur les seules côtes écossaises, les conditions locales entrant comme facteur principal dans la réussite ou l'insuccès du repérage par avion.

H. Heldt.
Directeur de la Station Océanografique
de Salammbô.

O. Pettersson. The Swedish saving trawl. Svenska Hydrografisk-biologiska Kommissionens Skrifter VI. (1925).

The original "Ridderstad saving trawl" was fully described in a paper entitled "A new construction of trawl intended to spare under sized fish" (Svenska Hydro. Biol. Komm. Skrifter VI 1915). In principle the saving apparatus consisted of a "window" inserted in the baitings and carrying "unalterable horizontal parallelogrammic meshes of such dimensions that both round fish and flat of certain size could escape through the frame work". In addition were added special devices for the protection of the saving part and for compelling the fish caught to pass close to the window. The long axis of the meshes was athwart the trawl.

The practicability of the original apparatus was, however, vitiated by the heavy iron frame work supporting the saving part, since it is obvious that any apparatus that is to find favour with, or at least be free from, the active opposition of the industry must be of a type more or less conforming to their conservative ideas and one which can be used with the minimum of extra trouble to the fishing crew.

The apparatus described in the present paper has entirely overcome the above objections, since the heavy iron framework has been replaced by cane struts which in no way interfere with the actual shooting, hauling or stowing of the trawl. The latest model which I had the privilege of seeing in action in the Research Vessel "Skagerak" by the courtesy of Prof. O. Pettersson is even simpler than that described, and I was satisfied that there was no objection to it from the point of view of the actual actions involved to fishing operations.

One trouble, however, seems to remain, namely that the saving panel is not an integral portion of the trawl net and the meshes are not of the type usually manufactured in net factories. This introduces complications in the making, fixing and lastly, but not least, the *mending* of the net at sea.

As regards the basic principle, i. e. the specially shaped mesh, the tables show that considerable numbers of undersized flat and round fish are saved, with apparently but small loss of marketable fish. The figures

would however, in my opinion have been more convincing had the different species been worked up separately.

Though there may be the above objections in detail to the present form of the saving trawl, and though the method of working up results may be criticized to a certain extent, there is no doubt that the principle of the mesh with unequal axes is sound, and constitutes a probable solution of the problem of saving undersized fish. Even if in detail the type of mesh has to be radically altered or modified to suit commercial conditions, the full credit for the inspiration must be given to the inventor of the rectangular mesh with unequal axes. F. M. Davis.

J. Travis Jenkins, D. Sc., Ph. D. The Fishes of the British Isles. Frederick Warne & Co., Ltd., London & New York 1925.

This book is described as a "Handy Pocket Guide with descriptive text" and admirably fulfils its function as a compact book dealing with British Fishes, so far as the illustrations and descriptions of the actual fishes themselves are concerned. From these anyone should be able readily to identify the fish.

The book opens with a preface in which the author gives his reasons for its publication; among these reasons is that Day's "Fishes of Great Britain and Ireland" (1880—84) is "hopelessly out of date"; yet on turning to p. 365 (wrongly given in the text as p. 367) we find Day's work in the brief bibliography which is headed "only modern and reliable works are mentioned"!

The Introduction contains some curious errors and statements. On p. 14 is a "diagram to illustrate scale reading". It is a line drawing of a fish covered with scales, showing the lateral line and a dotted transverse line; the only explanation in the text is that "scales afford a means of estimating the growth and age of fish." It may be conceived that either the author omitted to give the explanation or that the drawing was included accidentally; as it stands it means nothing. Exception must also be taken to the statement on p. 17 that "the only enquiries that have been made on an extended scale into the quantitative distribution of fish eggs and larvae are those made on the Continent." Such investigations have been very extensively carried out and the results published by the Ministry of Agriculture and Fisheries during recent years on the Plaice, Cod and Herring. The vexed question however of the desirability of hatching the eggs of marine fish is treated very reasonably and impartially in the Introduction.

As already stated, the purely descriptive portion of the book is valuable and had the author been content with this no adverse criticism would have been necessary. It would then have formed a standard work for many years both for popular and scientific purposes, but the author has given accounts of the life history of fish which do not show the same care that has been given to the descriptional part. The story of the life of the Salmon is good and shows a real knowledge of the most recent researches, but the same cannot be said altogether of the accounts given of the life

history of certain of the principal marine food fishes. They are very uneven in length, which is inevitable, since but little is known of the life of even some of the most important, but it is unfortunate that the author has not made use of more of the literature now available. For instance the account of the life history of the Mackerel pp. 62 and 63 is both brief and inaccurate. No mention is made of its food although this has recently been investigated by EHRENBAUM, and it is stated that spawning only takes place at a short distance from land. WOLLASTON's researches before the war showed that the eggs were widely distributed over the greater part of the North Sea; the fact that by far the greatest abundance of Mackerel are taken in the middle of the North Sea during the summer months would appear to substantiate his findings, and, for the North Sea at all events, to contradict Dr. JENKINS' assertion that "Mackerel approach the land in May when the spawning season commences and leave it again in Autumn when the spawning season is over."

The statistics dealing with the Cod are evidently deduced from very old reports since we are told that the Cod represent between 16 and 17 per cent of the British North Sea Catch of demersal fish. Never since 1907 have they constituted so small a proportion, — in the majority of years since that date they have accounted for 20 per cent. Again the Norwegian share of the catch of Cod is very much underestimated at 7 per cent. In 1919, 1920, 1921 and 1922 the Norwegians caught 17, 23, 22 and 27 per cent respectively of the North Sea Cod; similarly the British share which is given at 85 per cent has never been more than between 60 and 70 per cent in these years. But the author has throughout paid little attention to recent publications or such a statement as that on p. 137 that the method of collection of statistics by the English Central authority is made by means of areas classified according to depth would have been qualified, since this system was abandoned in 1920 in favour of rectangles each 1° of longitude and 30' of latitude — a method that has now been adopted by Scotland and is also used in several Continental reports involving statistical data.

In the account of the life history of the Plaice the author deals almost exclusively with the Plaice in the Irish Sea and almost entirely ignores the work carried out in the North Sea. Giving all due credit to the Irish Sea work it can hardly be said to be as valuable as that done in the North Sea where investigations have been carried out for a great number of years by English, Schottish and Continental investigators on a very much larger scale than has been possible for the small staff on the Western coast. Yet when discussing the age and growth of Plaice we read "the best method of determining the growth and age groups . . . . . is by measuring large numbers of individuals caught together on the same ground. This method has been followed with success by JOHNSTONE in the Irish Sea about 16,000 plaice having been examined by him in the years 1909—13." He then gives the modal length of Plaice in the Irish Sea of from 1—5 years as determined in this manner. Investigators are hardly likely to agree that this method is better than that carried out by the English and Continental workers who have examined the otoliths of a far greater number of Plaice over a longer period. In England alone over 16,000 otoliths have been

read since 1920. The estimation of age by measurements was early abandoned by research workers in the North Sea since it was found that it was vitiated by differences in the distribution of fish of the same age but of different size. Migrations of Plaice are dealt with on four pages and except for a casual reference to Plaice having been marked in the North Sea the discussion is concerned exclusively with the movements of a few Plaice in the Irish Sea. Anyone conversant with the subject is well aware that in the course of the North Sea investigations thousands of Plaice have been marked and their movements determined, whereas in the Irish Sea it is a matter of a few hundreds, but to the uninitiated it would appear that the Irish Sea work was of paramount importance and a very false impression would be obtained. It would be interesting to know the author's authority for the statement that the cessation of growth in winter is due to "the great scarcity of food" in that season. It is known that small Plaice bury themselves in the sand and feed but little in cold weather but that this is due to lack of food has not been proved as far as we are aware, while there is some little evidence to the contrary.

When writing of the Herring it is evident that the author has not revised his text with any thoroughness, since on page 257 he states that "the eggs, young and spawning grounds are well known" while on the following page he directly contradicts this by saying that "neither the spawning grounds nor the spawning habits of the Herring are well known." The discussion that follows the latter statement is very unconvincing and is obviously based on pre-war researches, since no reference is made to the findings in Russell and Borley's report on Herring Trawling 1922, Bowman's report of 1923 where the occurrence of "spawny" Haddocks was correlated with the more northern Herring spawning grounds, nor Wallace's "First report on Young Herring in the Southern North Sea and English Channel (1924)" where much information as to the Southern North Sea spawning grounds is given. The author would appear to have relied on works on the Norwegian Herring, when he says that they do not reproduce till they are 5 years old, which is true for those fish, but not for the English Herring which are mature at 3 to 4 years. Also "four generations" of English Herring do not escape the drift net, as can be seen in Hodgson's report "Some observations on the Scales and Growth of English Herring" (1925) which shows that samples from landings by drifters on the English coasts regularly contain a large proportion of 3 and 4 year old fish. The food of the Herring is not mentioned, in spite of the very full accounts that have been published recently; but further to enumerate omissions would be unprofitable. Enough has been said to show that as far as the life histories of fish are concerned this work should not be taken too seriously. This is very regrettable, since with but little additional labour a book could have been presented to the public which would have given a most valuable resumé of our present knowledge of the natural history of fish.

D. E. T-P.

Ad. S. Jensen. On the Fishery of the Greenlanders. Meddelelser fra Kommissionen for Havundersøgelser. Serie Fiskeri. Bind VII. Nr. 7. Copenhagen, 1925.

When, about a year ago, Dr. Johs. Schmidt prevailed on Prof. Ad. S. Jensen to give a brief account of his experiences at Greenland, a signal service was rendered to the fishing industry and to the literature of fisheries. The Danish Government in its solicitude for the well-being of the Eskimos has caused this vast colony to be virtually a closed book to travellers. This, doubtless, goes far towards explaining the limited knowledge the outside world has possessed of fish life in Greenland waters during an era when commercial fishing has been pushing further and further into northern seas. In consequence of this isolation there have been times when most extravagant rumours have gone about in fishing circles concerning Greenland, especially respecting the abundance of halibut.

Now from Prof. Jensen's fluent and excellently illustrated report "On the Fishery of the Greenlanders" we are enabled to begin to make actual comparison of the fish wealth of Davis Strait with that of better known Arctic Waters.

The first feature which comes prominently under notice is the different composition of the fish fauna as compared with, say, the well-known neighbouring banks round Iceland.

Among the fishes generally marketable in Europe are recorded:

Halibut.	Norway Haddock.
Greenland Halibut.	Cod.
Catfish (3 species).	Salmon.
Herring.	Char.

Notable among those missing are:

Plaice.	Haddock.	Ling.
Dab.	Whiting.	Coalfish.

The Greenland Eskimos have interest in several fish generally regarded unmarktable in most countries. These are:

Greenland shark.	Lumpsucker.
Polar cod (2 species).	Capelan.
Long rough dab.	Sea scorpions (several species).

From the material collected during the cruises of the "Tjalfe" in 1908 and 1909 sufficient is set out by Professor Jensen to cause his readers to look forward to the series of monographs now in the course of preparation. To the life history of several species some entirely new contributions have been made.

From the practical point of view the object of the expedition can be regarded as attained, for more than one new industry came into existence out of the findings of the scientists who took part in it. The last

mentioned outcome of the investigations must have been a great source of satisfaction to Professor JENSEN, who has recently re-visited the scenes of his earlier labours. Separate sections of his report deal with the development since 1909 of each of the undermentioned fisheries:

Greenland halibut.	Uvak (fiord cod).
Halibut.	Greenland shark.
Cod.	Salmon.

Space does not permit reviewing these developments here, but the service rendered to Greenland can be gathered from the fact that the export of Greenland halibut has grown from 702 barrels in 1910—11 to 2758 barrels in 1922—23. The export of cod has gone up from 23,500 kilos in 1912 to 681,000 kilos in 1923. It is, it seems, in the cod fishery that the Greenlanders must seek the basis of a great export fishery and it is interesting to find that the authorities are making provision so that the fishing population shall accustom itself to move from point to point along the coast with the fish. To this end curing facilities and transport are to be available at suitable spots. Some other European countries with their ready markets and better refrigerating facilities will have an eye to the halibut, the abundance of which at some spots is remarkable. Prof. JENSEN records how, when he offered the extremely low price of 4 öre per kilo (1/4 d per lb) for Greenland halibut taken from Agdluitsok Fiord, from which no halibut had previously been exported, 2,753 fish weighing 14 1/4 tons were brought to him in 17 days. And these had been caught by the natives in 198 fathoms on primitive fishing gear largely made up of old nails and hoop iron!

By studying Professor JENSEN's report those who seek these highly prized fish will surmount some of the difficulties which might otherwise be encountered. For example, clear proof is given that a deep sea thermometer can serve fishermen as faithfully in Davis Strait as the lead does in better known fishing regions. When in early summer the temperature of the water on the fishing banks was below freezing point there were no halibut: a very slight increase in water warmth and the fish appeared in their summer haunts. The cod are similarly affected. Many fishing skippers who trawled for plaice off the Murman Coast in May and June 1908, when fishing conditions there were little known, can recall a long spell of fruitless work for which there are now adequate explanations.

In conclusion, it may be mentioned that following up the success of some Norwegian vessels in Greenland waters in 1924, there was quite an invasion in the succeeding year. A large Norwegian fleet of line vessels was joined by trawlers from England and France. There were some successes and some sad disappointments. Nevertheless, taking into consideration the closed seasons enforced by ice on the sea surface, and areas closed to trawling by the glacial boulders strewn on the sea bed, we must subscribe to the faith the Danish scientists have in the future of their fisheries in Greenland.

GEORGE T. ATKINSON.

Notes.

The following report has been received from Dr. JOHANSEN:—

Cruise of the Danish research vessel "Dana" in Danish waters October 1925.

(Leader: Dr. A. C. JOHANSEN. Captain: G. HANSEN. Biologist: ERIK M. POULSEN. Planktologist: P. JESPERSEN. Hydrographer: AAGE J. C. JENSEN. Laboratory Assistant: S. WEIS FOGH).

The research vessel "Dana" was employed in fishery investigations in the waters between the Baltic and the North Sea and in the eastern part of the North Sea (E. of 6° E. long), from the 2nd to the 20th of October 1925. The main work dealt with was:—

1) Location of spawning places of autumn-spawning herrings.
2) Fishing experiments with otter-trawl in the Horns Reef area in order to explore frequency of the various year classes of plaice.

1) LOCATION OF SPAWNING PLACES.

A series of fishing experiments with ring-trawl of stramin (of 2 metres in diameter) was carried out in order to catch recently hatched herring larvae. Where the depth was more than 20 metres two hauls usually were taken simultaneously, one in the upper layer (less than 12 m depth) and one in the intermediate or lower layer.

The main results regarding catch of herring larvae of 5—9 mm length per 30 minutes' haul were as follows:—

Western Baltic. (22 Stations).

An important spawning place was found E. of Sjælland, Möen and Falster. Most larvae with yolk sac occurred at depths from 10—30 metres. Average catch of larvae: 96 specimens, largest catch: 1380 spec.

The Sound (between the lines: Gilbjerghoved -Kullen and Falsterbo —Stevns light) (14 Stations).

Spawning places evidently of very little importance in 1925. Average catch of larvae: 5 spec., largest catch: 46 spec.

Eastern Kattegat from off Kullen to off Læsö (11 Stations).

Very important spawning places occurred this year. The same was found in September-October 1922. — Average catch pr. 30 minutes' haul: 309 larvae, largest catch: 1918 specimens.

North Western Kattegat (4 Stations).

A small coast herring of little importance is spawning here. Largest catch: 3 larvae.

Southern Skagerak from off Marstrand to off Hanstholm (6 Stations).

Practically no larvae of 5—9 mm length occurred here. Larger larvae of autumn spawners not rare off Marstrand but probably transported by the currents from eastern Kattegat.

Jutland Bank and Little Fisherbank (8 Stations).

The spawning places here were evidently of little importance in 1925. Average catch of larvae of 5—9 mm: 3 spec., largest catch: 9 specimens.

Horns Reef area (5 Stations).

No catch of larvae of autumn spawning herrings. Same result obtained in the autumn of 1903—06.

2) EXPERIMENTS WITH OTTER-TRAWL IN THE HORNS REEF AREA (between 55° and 56° N. lat.).

Young plaice of III-Gr., IV-Gr. and V-Gr. very numerous, II-Gr. ordinary, I-Gr. scarce. Total results of investigations in 1920—1925 in the Horns Reef Area:—

Year-class	1920	rich
—	1921	—
—	1922	—
—	1923	normal
—	1924	poor
—	1925	probably normal, but new investigations needed.

3) PLANKTON.

Aurelia aurita and *Cyanea capillata* strongly dominating in volume over all other plankton organisms in the catches with ring-trawl. *Chrysaora* not rare in the Horns Reef area.

4) HYDROGRAPHY.

Salinity in the upper and the lower layers of the Kattegat normal. Temperature in the intermediate layer 1—2° C. higher than normal. At the southern slope of the Deep Channel in the Skagerak the Atlantic water (of 35,00 ‰ S.) occurred at a little higher level than normally (about 40 m depth at 57°44′ N., 9°04′ E.).

A Selected Bibliography of Marine Bionomics and Fishery Investigation.

Compiled by

E. J. Allen.

Director of the Marine Biological Laboratory, Plymouth.

The following bibliography, arranged according to subjects, is intended as a guide only to the complete literature. Preference is often given to papers which contain a summary of previous work and good detailed lists of literature.

The lists of papers dealing with certain general questions, which are subjects of particular discussion at the present time, are in some cases of a fuller character.

With regard to the order in which the references are arranged, as a rule those given first upon any subject may usefully be read first by the student seeking information, and more recent papers are usually given before those which are older and more classical. At the same time an attempt has been made to keep together the writings of individual authors upon any particular subject. Many references of a slighter character are included because they are found in journals which the biological student is not likely to consult in the ordinary course of his reading.

In the case of the literature on Fishes (Part II)[1], few references are given previous to 1903, the date at which the International Council published the valuable summary, "The Literature of the Ten Principal Food Fishes of the North Sea" (Publ. de Circonstance, No. 3, 1903).

My thanks are due to the staffs of the laboratories at Lowestoft and Conway, as well as to my colleagues at the Plymouth Laboratory, for many references to recent papers.

Marine Biological Laboratory, Plymouth
November 23rd, 1925.

E. J. A.

[1] To appear in the second number of the Journal.

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